FORMATION of TURKISH NORMS in GAIT ANALYSIS

by

Şule Yılmaztürk

M. D., Faculty of Medicine, Marmara University, 1999

Submitted to the Institute of Biomedical Engineering
in partial fulfillment of the requirements
for the degree of
Master of Science
in
Biomedical Science

Boğaziçi University
July 2005

FORMATION of TURKISH NORMS in GAIT ANALYSIS

by

Şule Yılmaztürk

APPROVED BY:

Doç. Dr. Mehmed Özkan (Thesis Supervisor)	……..
Doç. Dr. Halil Özcan Gülçür	……..
Yrd. Doç. Dr. Can Yücesoy	……..

DATE OF APPROVAL: July 2005

ACKNOWLEDGMENTS

I am deeply grateful to my thesis supervisor, Assoc. Prof. Dr. Mehmed Özkan for his academic guidance, support, friendly tolerance and patience. I am very grateful to Assoc. Prof. Dr. Halil Özcan Gülçür and Assist. Prof. Dr. Can Yücesoy for their invaluable helps and academic guidance.

I am extremely grateful to Mr. Ali Osman Üçkardeş, PT, for his invaluable help and support throughout my thesis project. Very special thanks are to be extended to Ms. Meziyet Eker, PT for her friendly collaboration.

I would like to express my gratitudes to Prof. Dr. Hıfzı Özcan for his invaluable support in my thesis.

I wish to thank all the participants who volunteered for this study, to the students from Mevhibe İnönü Kindergarten, İsmail Hakkı Tan Kindergarten, Hasan Tan Primary School, Sokullu Mehmet Paşa Primary School, Kemal Atatürk High School, and Istanbul University Physical Therapy and Rehabilitation Faculty. I also wish to thank the administrators and teachers of these schools.

I am grateful to my administrators for their support in my thesis and for their patience.

I would like to thank my family and my friends for their support and encouragement throughout my studies.

ABSTRACT

FORMATION OF TURKISH NORMS IN GAIT ANALYSIS

In this study, a normative database of basic gait parameters, kinematics and kinetic patterns for 181 normal subjects with the ages of four, five, seven, eight, nine, sixteen, seventeen, eighteen and twenty is reported. Means, standard deviations and ranges were calculated for 15 parameters in basic gait parameters, 32 parameters in kinematics and 48 parameters in kinetics. These parameters were divided according to age and sex. It was found that there are differences between the outputs of this study (Turkish norms) and system's current normative data in kinematic and kinetic data concerning all three planes of movement, especially in transverse plane. Additionally, these two normative databases with two standard deviations were compared with each other in evaluating the kinematic data of hip, ankle and knee joints of thirty children of all five-year-old age (Twenty normal children and ten children with Cerebral Palsy). Sensitivity values, specificity values, positive predictive values and negative predictive values of the two databases were calculated for six hip movements, six knee movements and six ankle movements. According to the results obtained, it can be stated that system's current normative database is not a proper reference database for Turkish population. In addition, the results support the strong need for a proper and reliable reference data for Turkish population in gait analysis. These results also suggest that precise evaluation of a gait disorder needs to be done by comparing the patient with her/his own population. Turkish normative database can serve as a sensitive, specific and reliable reference data for Turkish population in gait analysis. Besides, this study will become a basis for many other gait analysis studies for Turkish population.

Keywords- Turkish norms, gait analysis, basic gait parameters, kinematics, kinetics.

ÖZET

YÜRÜME ANALİZİNDE TÜRK NORMLARININ OLUŞTURULMASI

Bu çalışmada, dört, beş, yedi, sekiz, dokuz, onaltı, onyedi, onsekiz ve yirmi yaşlarındaki 181 normal kişinin temel yürüme parametrelerini, kinematik ve kinetik patternlerini kapsayan normal kişilere ait bir veri tabanı sunulmaktadır. Temel yürüme parametreleri ile ilgili 15, kinematic verilerle ilgili 32 ve kinetik verilerle ilgili 48 parametrenin ortalamaları, standart deviasyonları ve dağılımları hesaplanmıştır. Bu parametreler yaşa ve cinsiyete göre sınıflandırılmıştır. Bu çalışma sonucu elde edilen veriler (Türk Normları) ile sistemin halihazırda kullandığı normal verileri arasında, kinematik ve kinetik verilerde, özellikle yatay düzlemde olmak üzere, üç hareket düzleminin hepsinde farklar olduğu bulunmuştur. Ayrıca, iki standart deviasyonlu bu iki normallere ait veritabanı, hepsi beş yaşında otuz çocuğun (Yirmi normal çocuk ve on Serebral Palsili çocuk) kalça, diz ve ayak bileği kinematik verilerinin değerlendirilmesi konusunda birbirleriyle karşılaştırılmıştır. Altı kalça hareketi, altı diz hareketi ve altı ayak bileği hareketi için iki veritabanının duyarlılıkları, seçicilikleri, pozitif prediktif değerleri ve negative prediktif değerleri hesaplanmıştır. Elde edilen sonuçlara göre, sistemin halihazırda kullandığı normallere ait veritabanının, Türk populasyonu için uygun olmayan bir referans veritabanı olduğu söylenebilir. Ayrıca, sonuçlar, yürüme analizinde Türk populasyonu için uygun ve güvenilir bir referans veritabanının gerekliliğini şiddetle desteklemektedir. Bu sonuçlar, bir hastanın yürüme bozukluğunun en iyi değerlendirmesinin, hastanın kendi populasyon normalleri ile karşılaştırılarak yapılmasının gerekliliğini desteklemektedir. Türk populasyonu normallerine ait veritabanı, yürüme analizinde Türk populasyonu için duyarlı, seçici ve güvenilir bir referans veri tabanı olarak kullanılabilir. Ayrıca, bu çalışma, Türk populasyonu için birçok başka yürüme analizi çalışmasına temel teşkil edecektir.

***Anahtar Sözcükler*:** Türk normları, yürüme analizi, temel yürüme parametreleri, kinematik, kinetik.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS

TR	Turkish norms
USA	System's current normative database
h1 and h4	Flexion/Extension movements for right and left hip, respectively
h2 and h5	Abduction/Adduction movements for right and left hip, respectively
h3 and h6	Internal/External Rotation movements for right and left hip, respectively.
k1 and k4	Flexion/Extension movements for right and left knee, respectively
k2 and k5	Varus/Valgus movements for right and left knee, respectively
k3 and k6	Internal/External Tibial Torsion movements for right and left knee, respectively.
a1 and a4	Flexion/Extension movements for right and left ankle, respectively
a2 and a5	Pronation/Supination movements for right and left ankle, respectively
a3 and a6	Internal/External Foot Progression movements for right and left ankle, respectively.

LIST OF ABBREVIATIONS

SD	Standard Deviation
R_	Right
L_	Left
Dbl	Double
Max.	Maximum
St.	Stance
Min.	Minimum
Rot	Rotation
Ang	Angle
Abd	Abduction
Flex	Flexion
Ank	Ankle
Shl	Shoulder
Add	Adduction
Lat	Lateral
Fwd	Forward
Sw.	Swing
Lat	Lateral
Vrt	Vertical
Fwd	Forward
Frc	Force
GRF	Ground Reaction Force
Mom	Moment
Pwr	Power
RHS	Right Heel Strike
LHS	Left Heel Strike
N	Newton
Nm/Kg	Newton meters per kilogram

1. INTRODUCTION

1.1 History of Gait Analysis

Locomotion is described as a rhythmic movement that keeps the body in constant forward progression (Rose & Gamble, 1994) [1]. The study of the locomotion (walking and running), or gait analysis, has fascinated researchers since antiquity.

The reasons for studying human locomotion have changed over the centuries. The cave drawings in the Paleolithic Era depicted men and animals in motion such as moving from place to place, escaping from predators, and hunting for food. Even the Greek philosophers (500-300 BC) analyzed and described human movement with a need to place harmony to the universe (Lorini et al., 1992) [2]. They believed that the senses deceive and that no experimental method can lead to truth and so truth could only be reached by logical thought. By their philosophy, some relevant questions can be inferred about modern-day studies of human locomotion. If senses deceive, they will obviously limit the ability to observe and analyze human movement. Some early examples showing the limitations of senses can be seen in the depiction of horses while they were in motion, the artist drew the position of the horses' legs incorrectly (Dagg, 1977) (Figure 1.1) [3, 4]. It is obvious that the eye was not capable of capturing the sequence of rapid limb movements of horses in motion (Muybridge, 1887) [3, 5].

The first objective study on mechanics of gait was reported by the Weber brothers (Weber, W., Weber, E.) (1836) (*Die Mechanik der menschlichen Gehwerkzeuge*) who quantified trunk inclination, the alternation of the swing and stance phases, and the relationship between step duration and step length [6, 7]. Their work established a model for subsequent quantitative studies of human locomotion. The works of two contemporaries in the 1870s, Marey and Muybridge were among the first to quantify patterns of human movement using photographic techniques [3, 6]. Muybridge used a series of cameras to take multiple pictures in rapid succession of both animals and humans in movement [3, 5, 6]. Also during that time period, Braune (an anatomist) and Fisher (a

mathematician) (1895) reported measurements of body segment movements to calculate the accelerations, velocities, as well as moments of joint forces and energy expenditures using Newtonian mechanics [3, 8]. This study is the classic scientific study of human gait. Their theories are essentially the same as those used by current investigators in the area of biomechanics of gait (Paul J. P., 1967, Bresler, B. and Frankel, J., 1950, Paul J. P., 1975) [9, 10, 11].

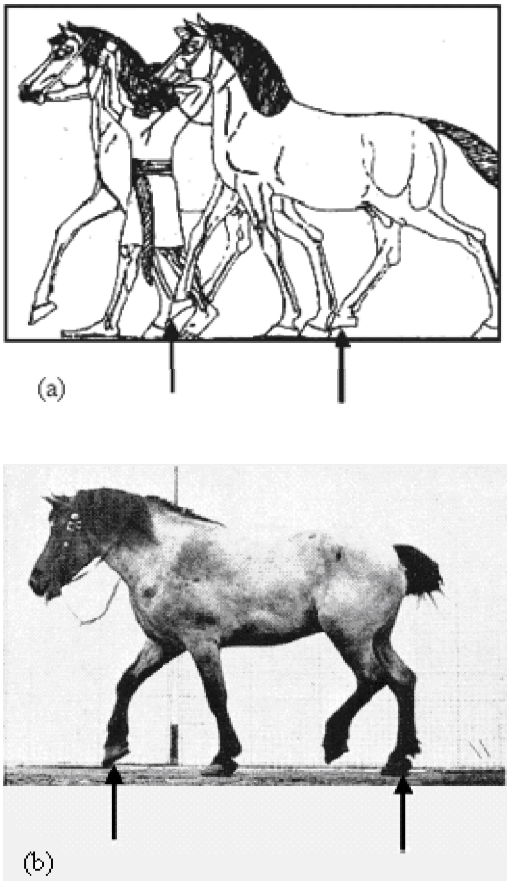

Figure 1.1 (a) An artist depiction of the gait of a horse (7 BC) indicates an incorrect pattern of limb movement (Dagg, 1977). The ipsilateral limbs of the horse in the drawing are simultaneously in swing or weight during phases. The eye of the artist could not sample at high enough rates to observe the correct pattern of limb movements visually. As illustrated in (b) from the photographic techniques developed by Muybridge (1877), the contralateral limbs of the horse are simultaneously in swing or weight during phases [3].

Further progress on the study of locomotion followed the development of force platform. Bresler and Frankel (1950) calculated the forces and moments at the lower limb joints during locomotion by applying inverse dynamics and taking into account the effects of gravity and inertial forces on limb segments [10]. The mechanical analysis described by

these researchers formed the basis of many current studies on the biomechanics of locomotion (Eng & Winter, 1995, Winter et al, 1990, Cappozzo, 1984) [12, 13, 14].

The studies at the University of California (Eberhart, 1947, Inman et al., 1981) [3, 15, 16] provided a tremendous resource of knowledge related to the mechanics of human movement and formed the basis for many of the fundamental techniques currently used for the study of human locomotion. More recently, the development of instrumentation and computer technologies have provided new opportunities for the advancement of the study of human locomotion. This new methodology has made it feasible to extend the application of kinetic analysis to clinical problems and allowed investigators to obtain and analyze accurate kinematics and kinetic data more quickly.

1.2 Computerized Gait Analysis System

Currently, the most frequently used method for measuring human movement is optical motion capture system which consists of a computer controlling several light-sensitive cameras placed on the skin's surface of the segment being analyzed (Varadarajan, 2002, Benedetti and Cappozzo, 1994) [17, 18]. The cameras capture the light in the field of view and measure the intensity of light for each pixel in the image. The performer wears spherical markers covered with a highly reflective tape. The cameras have shutter synchronization and are usually fitted with their own light source that creates a directional reflection from the markers. The views from the different cameras must be calibrated so that the computer knows the location of the different cameras and can determine 3D positions of the markers. At least three cameras are needed to determine a 3D point in space from 2D images. The advantages of an optical system include large performance areas proportional to the number of cameras, markers can be moved depending on the object to be captured, and the performer is not seriously constrained by the markers. The major disadvantages are extensive post-processing, a controlled environment, and occlusion of markers, which to some extent is overcome by having redundant camera coverage from all sides [18].

The computerized gait analysis system consists of planning, capturing, data processing, and data analysis. The most important point about using this system is to avoid problems by planning well ahead. After capturing, data processing consists of reconstructing the data from the different camera views to produce 3D positional data and labeling the markers. Once this has been done any noise in the data needs to be filtered and gaps in the data due to occlusion of markers needs to be filled [18].

Planning a capture session involves understanding the objectives of the capture. There must be a ready project to determine the character and marker setup of any characters or props to be motion captured. Character setup deals with locations of joints or bones in the body of the character that will provide final motion and deformations. Marker setup pertains to the locations of markers that are used to collect the data. When designing the marker setup for the project, at least three markers are needed per rigid segments and the markers must be placed close to the bone to reduce marker sliding on the skin. In addition, markers should be placed on rigid segments asymmetrically so that, for example, the software can determine the left arm from the right arm [18].

Computerized gait analysis systems are superior to the standard analysis systems because:

- the eye is too slow (a human eye can see twelve events simultaneously, flicker-fusion rate about 12 Hz) [19],
- motion leaves no record,
- internal forces and moments [torques] can be measured,
- muscle activities can be analyzed by dynamic electromyography.

Gait analysis is the process of determining the cause of abnormalities in a patient's walking pattern and so that those abnormalities can be treated effectively and the patient's functionality can be improved. A gait analysis session consists of several steps including physical examination of the patient, and collecting quantitative data about the patient's motion, muscle activity, and forces exerted over time. All of the information is either collected by computer or entered into a computer and resides in electronic forms. In addition, video of the patient walking can be recorded. These data are then used to generate a gait analysis report.

Computerized gait analysis is useful in quantitative and objective documentation of walking ability and identifying the underlying causes for walking abnormalities in patients with cerebral palsy, stroke, head injury and other neuromuscular problems. Gait analysis may be used to follow a patient's progress across a period of time, and their response to a particular form of treatment. It may also be used to document how well a patient walks, in comparison with normal people, and in comparison with other people affected by the same condition. The results of gait analysis have been shown to be useful in determining the best course of treatment.

Gait analysis is also a powerful research tool: It may be used to provide better information on diseases that affect walking, and to compare different types of treatment. Being based on engineering mathematics, it gives precise scientific data, which may show up small but significant differences between patients who have been treated in different ways.

Currently, gait analysis consists of:

- Physical therapy assessment,
- Visual gait analysis using video cameras,
- Measurement of basic gait parameters (spatial and temporal parameters, spatiotemporal parameters),
- Analysis of joint motion using infrared cameras (kinematics),
- Analysis of joint force, joint moment, joint power and ground reaction forces using force platforms (kinetics),
- Analysis of muscle activity using dynamic electromyography (surface or fine-wire),
- Detailed further analysis and reporting based on all the above information.

1.3 Normal Gait

The term “gait” is used to describe “a particular manner or style of walking”, and the term “normal gait” is used to present those parameters that have been generalized across sex, age, genetic predisposition and anthropometric variables [20, 21].

The gait cycle is defined as the time between two successive occurrences of one of the repetitive events of walking. In other words, it is defined as the period from heel contact of one foot to the next heel contact of the same foot (Figure 1.2) [16, 20, 21, 22, 23, 24].

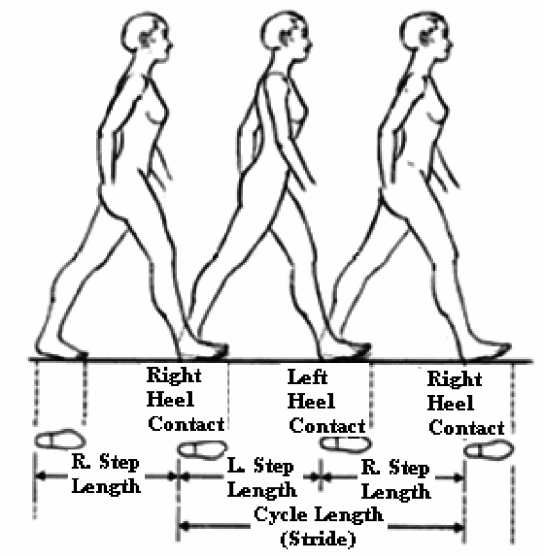

Figure 1.2 Distance dimensions of the gait cycle [24].

This cycle is broken into two parts, stance phase and swing phase. Stance phase is the phase when the foot is on the ground. Swing phase is the phase when the foot is moving forward through the air. On the average, the gait cycle is about one second in duration with sixty percent in stance and forty percent in swing. Two additional periods of double-limb support exist when both the right and left lower extremities contact the ground in opposite synchronization (Figure 1.3) [16, 20, 21, 22, 23].

The swing phase of the gait cycle is the non-weight bearing phase and is further subdivided into initial swing (acceleration) (ISw), midswing (MSw) and terminal swing (deceleration) (TSw). The stance phase of the gait cycle is subdivided into initial contact (IC), loading response (LR), midstance (MSt), terminal stance (TSt), preswing (PS), (Figure 1.4) [21, 22, 23].

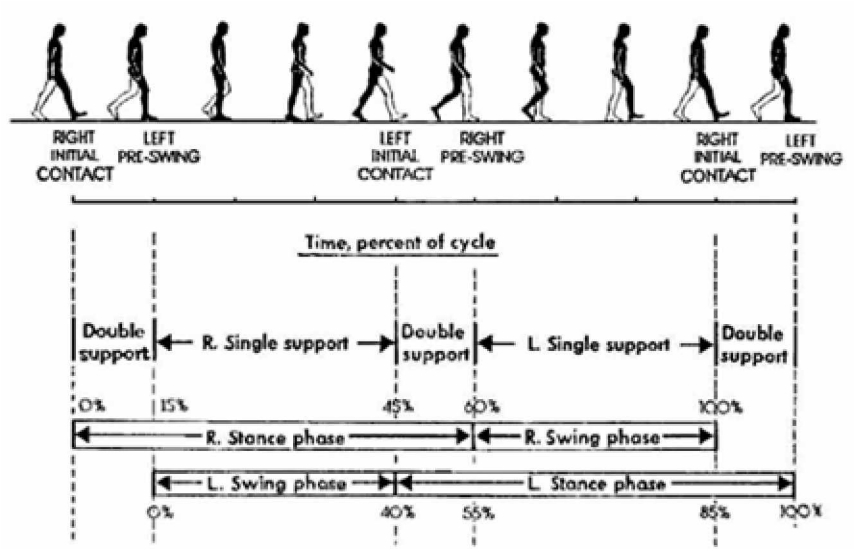

Figure 1.3 Time dimensions of the gait cycle [24].

Loading Response (LR)

- Comprises 2-10% of the gait cycle.
- Weight acceptance and shock absorption are maintained, forward movement of the body starts.
- Kinematics:

  Hip - 30º of flexion

  Knee - 0º to 15º of flexion

  Ankle - 0º to 15º of plantarflexion [20].

Midstance (MSt)

- Comprises 10-30% of the gait cycle.
- Single limb support, forward progression of the body continues over single limb.

- Kinematics:

  Hip - 30º of flexion to 0º

  Knee - 15º of flexion to 0º

  Ankle - 15º of plantarflexion to 10º of dorsiflexion [20].

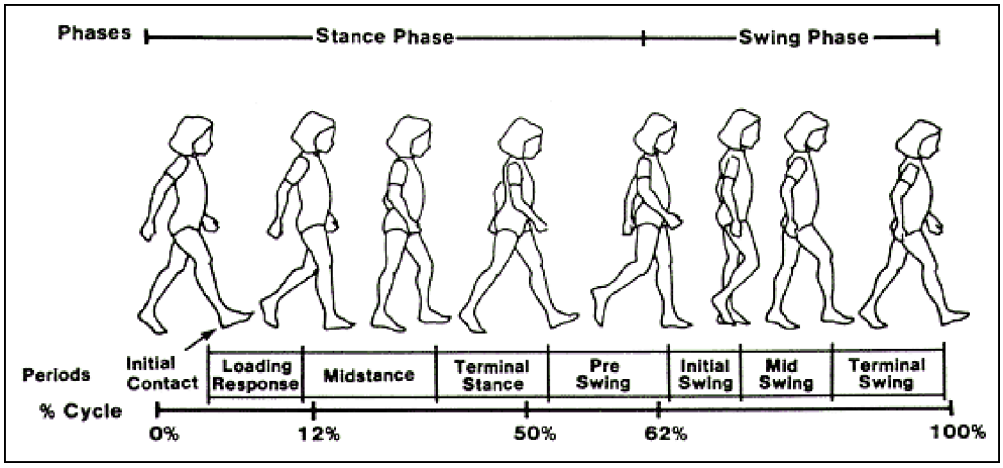

Figure 1.4 Subphases of the gait cycle [25].

Terminal stance (TSt)

- Comprises 30-50% of the gait cycle.
- Single limb support, the body passes over foot and forward progression of the body accelerates.
- Kinematics:

  Hip - 0º to 10º of hyperextension

  Knee - 0º [neutral position]

  Ankle - 10º of dorsiflexion, foot fingers - 0º to 30º of hyperextension [20].

Preswing (PS)

- Comprises 50-60% of the gait cycle.
- Limb in swing phase is progressed forward; limb to be in swing phase is prepared for foot clearance.
- Kinematics:

  Hip - 10º of hyperextension to 0º

  Knee - 0º to 35º of flexion

Ankle - 10º of dorsiflexion to 20º of plantarflexion [20].

Initial swing (Isw)

- Comprises 60-75% of the gait cycle.
- Limb in swing phase is progressed forward.
- Kinematics:

  Hip - 0º to 20º of flexion

  Knee - 35º to 60º of flexion

  Ankle - 20º of plantarflexion to 0º [20]

Midswing (MSw)

- Comprises 75-90% of the gait cycle.
- Limb in swing phase is progressed forward.
- Kinematics:

  Hip - 20º to 30º of flexion

  Knee - 60º to 30º of flexion

  Ankle - 20º of plantarflexion to 0º [20].

Terminal swing (TSw)

- Comprises 90-100% of the gait cycle.
- Limb in swing phase is progressed forward, maximum step length is achieved, foot is prepared for proper position of initial contact, limb is swing phase is decelerated.
- Kinematics:

  Hip - 30º of flexion

  Knee - 30º of flexion to 0º

  Ankle - 0º [neutral position] [20].

Seventy percent of the total body mass is located in the head-arms-trunk segment. This mass progresses in a hypothetical line of progression and is balanced during ambulation on the lower extremities, which form the remaining thirty percent of total body mass. The body's ability to effectively balance this mass in both static and dynamic situations is essential to the functional goals of bipedal ambulation [21, 23].

These goals include providing a stable base of support in stance, allowing forward progression of the body mass over the distal limb segments, maintaining minimum energy expenditure, and employing appropriate mechanisms for shock absorption and dissipation of forces. It should be understood that the timing of muscle actions to produce specific joint motions is critical for a stable, efficient bipedal mode of ambulation. Even minor disturbances of the neurological control mechanisms, motor input and structural skeletal alignment can have a significant effect on dynamic stability and on functional and energy-efficient gait [21].

1.4 Components of Gait

1.4.1 Basic Gait Parameters

Basic Gait Parameters are calculated according to gait cycle, and are divided into two main categories as temporal and distance (spatial). Cadence, gait cycle duration, stance and swing times, single limb support, and initial and terminal double limb support are typical parameters measured. By making the measurements over a defined walking distance, average velocity and stride length also can be defined [26].

***Temporal parameters*:**

- *Stance* and *swing time*,
- *Single limb support time, initial and terminal double support time,*
- *Velocity*, which is the distance covered by the whole body in a given time and is measured in meters per second.
- *Cadence*, which is the number of steps taken in a given time, the usual units being steps per minute [20].

Distance parameters:

- *Stride length*, which is the distance between two successive placements of the same foot.

- *Step length*, which is the distance one foot moves ahead of the other foot during the gait cycle [20].

1.4.2 Biomechanical Concepts

Biomechanical concepts related to gait analysis are time, mass, force, center of gravity, moments of force, and motion – both linear and angular.

Time

The second (s) and the millisecond (ms) are the primary units for time measurement in biomechanics, although it is common to fond walking speed quoted in meters per minute or even miles per hour. When repeated events occur at short intervals of time, it is usual to quote a frequency in hertz (Hz), 1 Hz being one cycle per second. The relationship between sample interval and frequency is given by [20]:

Interval (ms) = 1000/frequency (Hz)

Mass

The mass of an object is the amount of matter contained in it, which does not depend on whether any gravity is present. However, weight is the force exerted by gravity on the subject [20].

Force

Force is a vector quantity, which means that it has both magnitude and direction. The unit of force is Newton (N). The force applied by normal earth gravity to a mass of one kilogram is 9,81 N.

Science of mechanical engineering is based on the three laws of force propounded by Sir Isaac Newton:

Newton's first law: A body will continue in a state of rest, or of uniform motion in a straight line, unless it is acted upon by an external force.

Newton's second law: An external force will cause a body to accelerate in the direction of the force. The acceleration (α) is equal to the size of the force (F) divided by the mass (m) of the object, as in the equation:

$$\alpha = F/m$$

Newton's third law: To every action, there is a reaction, which is equal in magnitude and opposite in direction [20].

During gait, when the foot is in contact with the ground it applies a force to the ground and a *Ground Reaction Force* (GRF) is developed that is equal and opposite to the force the foot applies on the ground. GRF is the external force acting on the body while walking. The only other external force acting on the body is gravitational attraction if wind resistance or drag is neglected. A force plate that is mounted securely in the floor such that its surface is flush with the floor measures the force the foot applies to the ground. The force plate has an instrument center that is below the floor and the resultant force and moment about this instrument center is measured. These data are sampled at a specific rate, usually 1000 Hz, or every millisecond. The resultant force and moment are expressed in an equivalent force system composed of the resultant force acting at a specific point on the surface of the force plate and a torque about the vertical axis. The resultant ground-reaction force is divided into three components: vertical, anterior/posterior, and medial/lateral. The torque is called the ground reaction torque and the unique point of the intercept of the GRF with the force plate surface is called the center of pressure (COP) or the center of force. The COP changes during stance phase generally moving from the rear of the foot anterior toward a point between the first and second metatarsal heads. The path of the COP on the force plate can be related to the path of the resultant ground-reaction force on the plantar surface of the foot. If an actual pressure distribution plot were obtained at an instant during stance phase, the COP would be the centroid of the pressure distribution [26].

Center of Gravity

Although the mass of any object is distributed throughout every part of it, it is frequently convenient, as far as the effects of an applied force are concerned, to imagine that the whole mass is concentrated at a single point, which is called the center of gravity (C of G). The center of gravity of the body is just in front of the lumbosacral junction for a person standing in the anatomical position [20].

Moment of Force

Moment of force is the perpendicular distance from the fulcrum, may also be referred as the torque, the turning moment, or simply the moment. The formula for calculating moment of force is:

$$M = F \times D$$

where M is the moment of force (in Newton-meters, Nm), F is the force (in Newtons, N), and D is the distance (in meters, m).

The measurement and interpretation of moments of force is essential for fully understanding of gait. Active internal moments are generated by muscular contraction. Passive internal moments are produced by bone-on-bone forces, and by tension in the soft tissues, especially ligaments. Moments may also be transmitted from adjacent joints. External moments (sometimes referred to as reaction moments) are generally due to gravitational forces.

In the same way that Newton's third law states for force, every moment of force is opposed by another equal and opposite moment. It is impossible to generate a moment unless there is something to 'push back' with an opposing moment.

Any object that is supported by the ground will remain stable so long as the line of gravity (the line of force passing vertically downwards from the center of gravity) remains within the area on the ground that is supporting it. Should the line of gravity stray outside

this area, one of the two things can happen – it may automatically correct itself, as happens with a self-rightening lifeboat, or it may fall over, as will happen with a pencil balanced on its point. The former is a *stable equilibrium*, where a degree of imbalance produces restoring moments, which push the object towards the balanced position. The latter is an *unstable equilibrium*, where the moments act to increase the imbalance. When walking at moderate speeds, a further condition exists – a *dynamic equilibrium*, where from instant to instant the equilibrium is unstable, but before there has been time to fall the area of support is moved and equilibrium is restored [20].

Linear Motion

Acceleration is the rate at which velocity changes, the change may be in either magnitude or direction. An unchanging velocity has an acceleration of zero, a decrease in velocity may be known as negative acceleration, deceleration or retardation. If the velocity is measured in meters per second, the acceleration will be in meters per second per second [20].

Circular Motion

An object that is rotating has an angular velocity, and if the angular velocity changes there is an angular acceleration. In walking, the leg has an angular velocity and undergoes angular acceleration and deceleration. In the same way that linear acceleration depends on the presence of a force, angular acceleration will only occur if there is an application of a moment of a force.

Angular velocity is measured as angle turned per unit time, usually as degrees per second or radians per second. Angular acceleration is similarly expressed in degrees (or radians) per second per second.

When a force applied to an object produces an angular acceleration, the acceleration does not depend solely on the size of the force and the mass of the object, as it does with linear motion. It also depends on the way in which the mass is distributed about the center of gravity – a property known as the *moment of inertia*. An object with the mass

concentrated around the outside, such as a flywheel, has a much higher moment of inertia than with a mass concentrated around the center, such as a cannonball. Although if they have the same mass, the flywheel will be much more difficult to stop rotating than the cannonball, because of its higher moment of inertia [20].

Inertia and Momentum

Inertia is the resistance offered by a body to any attempt to set it in motion, or to stop it if it is already moving. In the case of linear motion, it results from the mass of the object, and in the case of rotational motion, it results from the moment of inertia.

Momentum exists in two forms – linear and angular. The *linear momentum* [generally just called momentum] of a moving object is calculated by multiplying its velocity by its mass. The *angular momentum* of a rotating object is calculated by multiplying its angular velocity by its moment of inertia. Law of conservation of momentum states that momentum cannot be created or destroyed merely transformed from one object to another [20].

Kinetics and Kinematics

Kinetics is the study of forces, moments, masses and accelerations, but without any detailed knowledge of the position or orientation of the objects involved. For example, an instrument known as a force platform is used in gait analysis to measure the force below the foot during walking, but it gives no information on the position of the limb or the angle of the joints.

Kinematics describes motion, but without reference to the forces involved. An example of kinematics instrumentation is a camera, which can be used to observe the motion of the trunk and the limbs during walking, but which gives no information on the forces involved. It is obvious that for an adequate quantitative description of an activity such as walking, both kinetic and kinematics data are needed [20].

Work, Energy and Power

Work is done when a force moves an object a certain distance. It is calculated as the product of the force and the distance. The unit of work is joule [J].

Energy is the capacity to do work, and is also measured in joules. It exists in two basic forms – *potential* (or stored) energy and *kinetic* (or movement) energy. In walking, there are alternating transfers between potential and kinetic energy.

Power is the rate at which work is done – a rate of one joule per second is a watt. In a rotary movement, when a joint flexes or extends the power (P) is calculated as the product of the moment of force (M) and the angular velocity, omega (ω):

P (watts) = M [Newton-meters] x ω (radians per second)

When a muscle is contracting concentrically (e.g. a flexor muscle contracts while a joint is flexing), power is generated. If a muscle contracts eccentrically (e.g. a flexor muscle contracts while a joint is extending), it absorbs power. If a muscle contracts isometrically, no power exchange takes place. Ligaments and other soft tissues also involve power exchange. If a ligament is stretched, it absorbs power, with a resulting storage of potential energy. Some or all of this stored energy may be released later, with a resulting power generation [20].

In biomechanics, the human musculoskeletal system is viewed as a series of linked segments (Figure 1.4.2.1), which are defined as rigid bodies. Two frames of reference are used for discussing human motion or kinematics. There is the Newtonian or global frame of reference, which divides the motion laboratory space into 3-planes (Figure 1.4.2.1). Each body segment can be described as having up to 6-degrees of freedom (DOF), which can describe the location and orientation of that segment in space. In other words, motion can be discussed with respect to the global frame of reference, which includes moving forward or backward in the sagittal plane, side to side in the frontal plane, or inward or outward in the transverse plane [27].

Figure 1.5 illustrates a body with 17 linked segments and demonstrates the *X*, *Y*, and *Z* axes which define the Newtonian or absolute frame of reference. The plane formed by YZ is the frontal plane - 1, XZ is the sagittal plane - 2, and XY is the transverse plane - 3 [27].

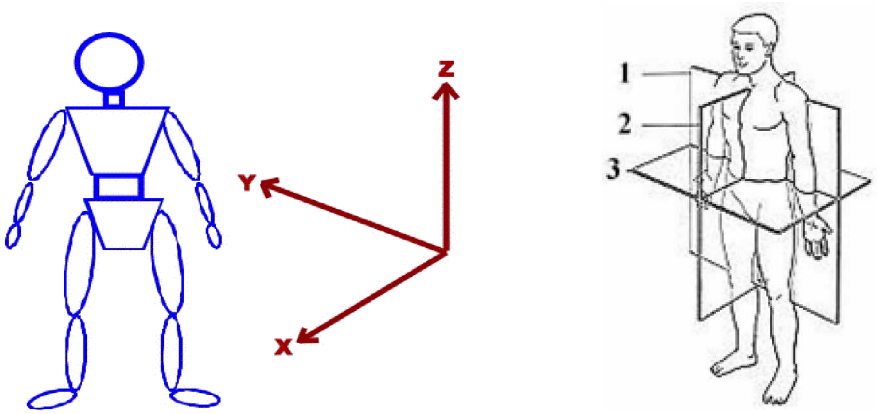

Figure 1.5 Linked body segments. 3-D axes for global frame of reference. Planes of Motion: 1 = Frontal plane, 2 = Sagittal plane, 3 = Transverse plane [27].

Table 1.1 shows body planes of the movement. Movements of flexion and extension take place in the sagittal plane. Movements of abduction and adduction (lateral flexion) take place in the frontal plane. Movements of medial and lateral rotation take place in the transverse plane.

Table 1.1 Body Planes of Movement.

Plane of Movement	**Joint Movement**	**Axis**
Sagittal	Frontal (x)	Flexion and extension
Frontal	Sagittal (antero-posterior) (z)	Abduction and adduction (lateral flexion)
Transverse	Longitudinal (vertical) (y)	Medial and lateral rotation (axial rotation)

Normal bipedal gait is achieved with a complex combination of automatic and volitional postural components. Normal walking requires stability to provide antigravity support of body weight, mobility of body segments and motor control to sequence multiple segments while transferring body weight from one limb to another. The result is energy-efficient forward progression [28].

1.5 Motivation and Objective

When pain, paralysis or tissue damage occurs, abnormal gait is the result. Loss of motor control will also result in a gait disorder. When physicians are confronted with pathological gait, they must have sound knowledge of the characteristics of normal gait so that they can accurately detect and interpret deviations from the normal gait pattern. This is simply a comparison between the patient and a healthy unimpaired individual of similar age and gender. However, it is important to keep in mind that each individual displays certain variations from the norm that are superimposed on the normal pattern of walking. Medical work from Murray supports the view that "if all gait movements are considered, then gait is unique" [29, 30]. Furthermore, this approach is supported by biomedical gait researches, which found that the dynamics of a certain number of body parts totally characterize gait. There is a rich literature, also in other sciences such as mathematics and psychology which also suggest that gait is unique, indicating the potential for gait in personal identification (Foster et al, 2001, Nixon et al, 2004) [31, 32]. Considering that every human has a unique body, he/she has to have a unique gait pattern. That should be the reason why gait analysis systems have to use broad normal intervals. Because the aim of treatment is to restore function, a normative database is desirable. This is a large task because the database must account for the broad spectrum of what is regarded as normal, including differences not just in gender and age but also among people in different geographical locations and of different cultural backgrounds. The most common sources of normative data are those collected on "control" groups that are included in studies on pathological gait patterns for the purpose of comparison. Examples include elderly fallers, people with depression, detoxified alcoholic men, and hemiplegia. In a study published by the Journal of Rehabilitation Research and Development (Al-Obaidi et al, 2003), measurements of the spatiotemporal gait parameters of healthy young adult Kuwaiti

subjects from both genders were obtained to compare the data with those collected in a similar study performed in Sweden (Öberg et al, 1993) [33, 34]. The results indicate several significant differences between Kuwaiti and Swedish subjects in their manner of walking. In another study from Hong Kong, a group of 11 boys and 9 girls aged 10–12 were examined and the results were compared with data resulting from an American research. Significant differences were found between the walking patterns of the two populations [35]. These results suggest a need to include data from subjects with diverse cultural backgrounds when a database on normal gait is developed, a need to limit the results of the database to a specified ethnic population, and the need for establishing pathological gait analysis standards for various populations (environments).

Because minute differences can cause very different results in gait analysis, the analysis of a person should be performed according to her/his population normal values in order to get more accurate and more reliable results. Besides, instrumented quantitative gait analyses have not been systematically adopted for the evaluation of gait in other populations. Optoelectronic tracking systems and their implementation often differ from laboratory to laboratory. The data from one laboratory may differ in content, sensitivity to error, or reliability compared to the data from another. These differences could be attributed to different camera resolutions and calibration, different corrections for lens non-linearities, different camera setups, different ray-tracing algorithms, different marker sets, and even different methods for applying the same marker set [36]. Therefore, for a gait laboratory, it is necessary to have its own normative database.

There have been various studies about forming normative data in gait analysis, of basic gait parameters, kinematics, kinetics, and muscle activities [34, 37, 38, 39, 40]. The influences of motor control development, body size, age, and gender on gait data have also been explored [37, 38, 39, 41, 42, 43].

The objective of this study is the formation of normal curves for Turkish population in gait analysis.

2. METHODOLOGY

2.1 Instrumentation

Eight high-speed Falcon high-resolution video cameras (Motion Analysis Corp.) were positioned at various locations in Erol Sabancı Motion Analysis Center laboratory to sample kinematic data at 60 Hz. The cameras were positioned to allow each of the 22 retroreflective markers placed on the subjects to be seen by at least three cameras in each frame. Reflective markers were placed - using Helen Hayes Marker Set, which had been used while forming system's current normative data - over anatomic locations on the pelvis and lower extremities to estimate the locations of the hip, knee, and ankle joint centers and subsequently to allow for the computation of joint kinematics during walking. Two force platforms, recording at 1200 Hz and embedded in the center of the walkway, measured the ground reaction forces. Subjects had to perform ten successful crossings over the force platforms at their normal walking speed.

All video and analog data were collected by using the EVa HIRES 4.0 hardware-software system (Motion Analysis Corp.) and stored on the tracking computer. Video data were tracked and smoothed using a Butterworth fourth order low-pass filter with a cut-off frequency of 6 Hz in the EVa 4.0 software and then were exported to the OrthoTrak 5.0.3 software (Motion Analysis Corp.) for analysis. Three-dimensional joint angles for the trunk, hip, knee, and ankle were determined.

In Erol Sabancı Motion Analysis Center laboratory, EVa HIRES (Motion Analysis Corp., Santa Rosa, CA) is used for video and analog data acquisition and processing. It is a completely integrated hardware-software system. Under a single software environment setup, calibration, capturing motion in real-time, capturing motion for post processing, editing and saving data in the format of choice can be performed.

EVa HIRES (Motion Analysis Corp.) is able to acquire and display three-dimensional data with little or imperceptible time delay at the same instant as the subject is performing a specific task of interest. The system includes (Figure 2.1):

- eight Falcon high resolution analog cameras (Motion Analysis Corp.),
- a video processor computer MIDAS (Motion Analysis Corp.),
- a tracking (host) computer, two AMTI force plates (Advanced Mechanical Technology Inc., Watertown, MA, model OR6-5),
- two AMTI Mini Amp Strain Gage Amplifiers (Advanced Mechanical Technology Inc., model MSA-6) (for force plate data),
- Myopac [one Myopac Receiver/Decoder Unit and one Myopac 27 Channel Amplifier/Encoder/Fiber Optic Transmitter Unit (Run Technologies Scientific Systems, Santa Maria, Mission Viejo, CA)] for collecting dynamic EMG (electromyography) data,
- one video camera, and
- the software EVa (Motion Analysis Corp.).

		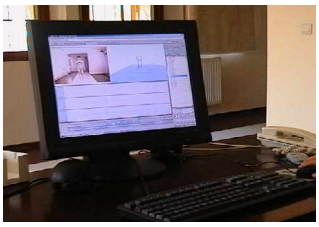
Infrared Analog camera	Video processor computer	Tracking (host) computer
		
Walking platform and embedded force plates	Amplifiers for force plate data (top two)	Receiver /Decoder Unit and Amplifier/Encoder /Fiber Optic Transmitter Unit for EMG data

Figure 2.1 Components of EVa HIRES (Motion Analysis Corp.).

The infrared cameras are capable of frame rates up to 240 Hz (60/120/240Hz switch-selectable). Additionally, they can determine one hundredth (1/100) of a millimeter. The normal person can see up to *twelve events* simultaneously (flicker-fusion rate about 12 Hz) [19].

AMTI force plates (Advanced Mechanical Technology Inc.) simultaneously measure three force components along the x, y, and z-axes and three moment components about the x, y, and z-axes (Figure 2.2). The forces and moments are measured by foil strain gauges attached to load cells at the four corners of the platform. Three of the output voltages are proportional to force and three are proportional to moment [45].

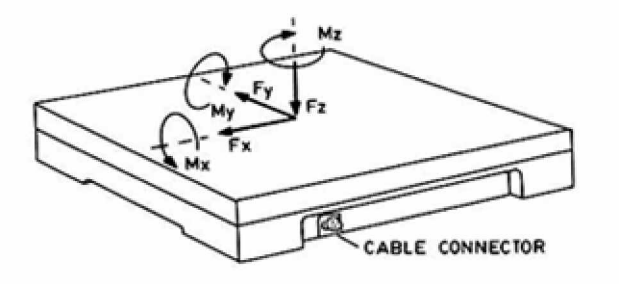

Figure 2.2 Axial system of a force plate (Advanced Mechanical Technology Inc.).

The output of the force plates are then sent to the high-gain amplifier, which provides excitation and amplification for each channel of the force plate [45]. The output from the amplifiers can then be fed into the video processor computer, which is an analog to digital converter A/D converter for the force plate data.

Myopac (Run Technologies Scientific Systems) is a telemetric system that employs a single digital fiber optic cable to transmit 27 channels of data from the small, lightweight, belt-worn transmitter unit to the remote receiver unit. The system collects dynamic EMG data with paired surface electrodes.

The Video Processor computer accepts video input from the motion capture cameras and produces data consisting of the coordinates of the outlines of the images of the retro-reflective markers. It also accepts analog input from force plates to produce kinetic data, and Myopac (Run Technologies Scientific Systems) data to produce muscle

activity data. EVa HIRES (Motion Analysis Corp.) can accommodate up to 64 analog channels for data from force plates, EMG.

The tracking computer accepts analog camera video image data and force plate data from the Video Processor computer via Ethernet connection. It also accepts video camera data directly. This computer is used to configure the system, collect data, and produce results.

The EVa software allows to:

- Initialize and calibrate the system.
- Setup, save, and recall project parameters for frequently used protocols.
- Select cameras, sample rates, and duration for data collection.
- Preview and display digitized video data.
- Set video processing threshold and masks.
- Select and set sample rate and gain for the analog cameras [46].

Retro-reflective markers are placed on the skin's surface of the segments being analyzed. While the person walks on the walking platform, the infrared cameras determine these markers, and the computer supplies three dimensional display- different views and angles, two dimensional display- digital grayscale and threshold images, and color video display. The markers are photographed in motion by an eight-camera optoelectronic motion capture system and an integrated digital video recording system. Force plates in the walkway/treadmill gather kinetic data as the subject walks over them (Figure 2.3).

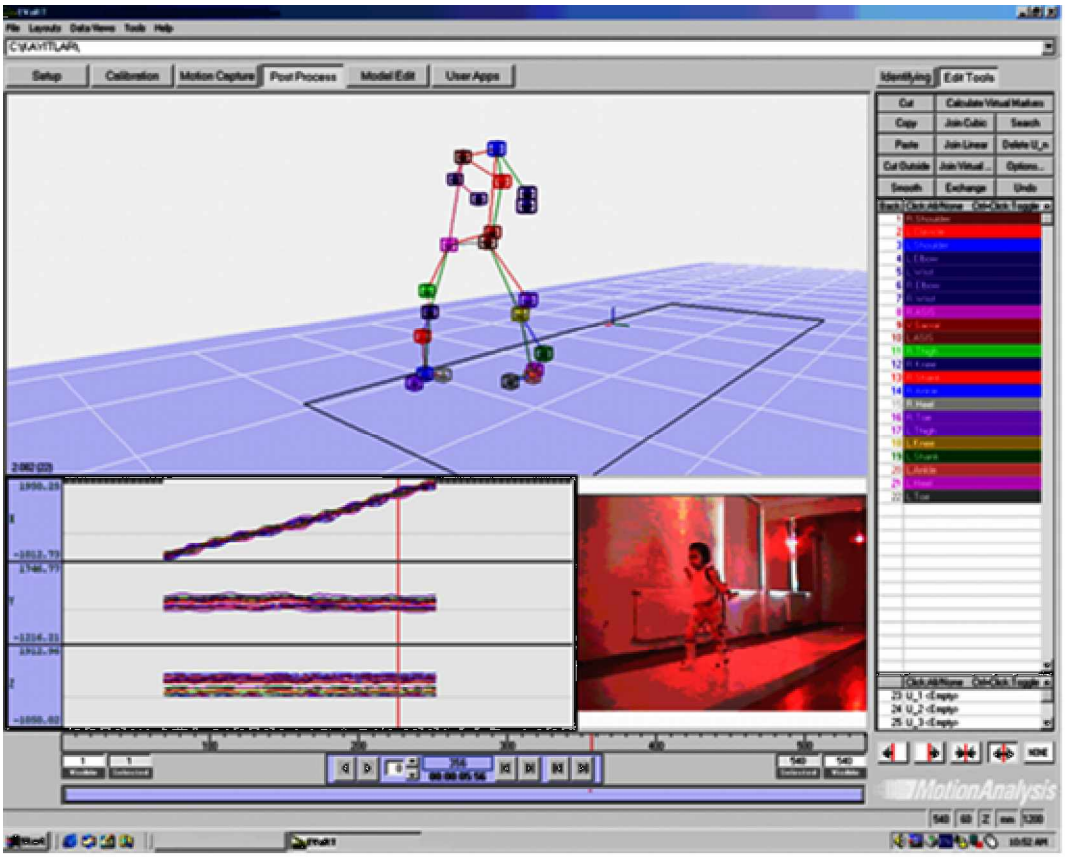

Figure 2.3 Motion capture with EVa HIRES (Motion Analysis Corp.).

A computer workstation equipped with a full suite of motion analysis software OrthoTrak Software System (Motion Analysis Corp.) provides an inverse dynamics analysis of the gait data (Figure 2.4), and forms graphical outputs (Figures 2.5 and 2.6). This system allows a fully automated, three-dimensional, clinical gait measurement, evaluation and database management.

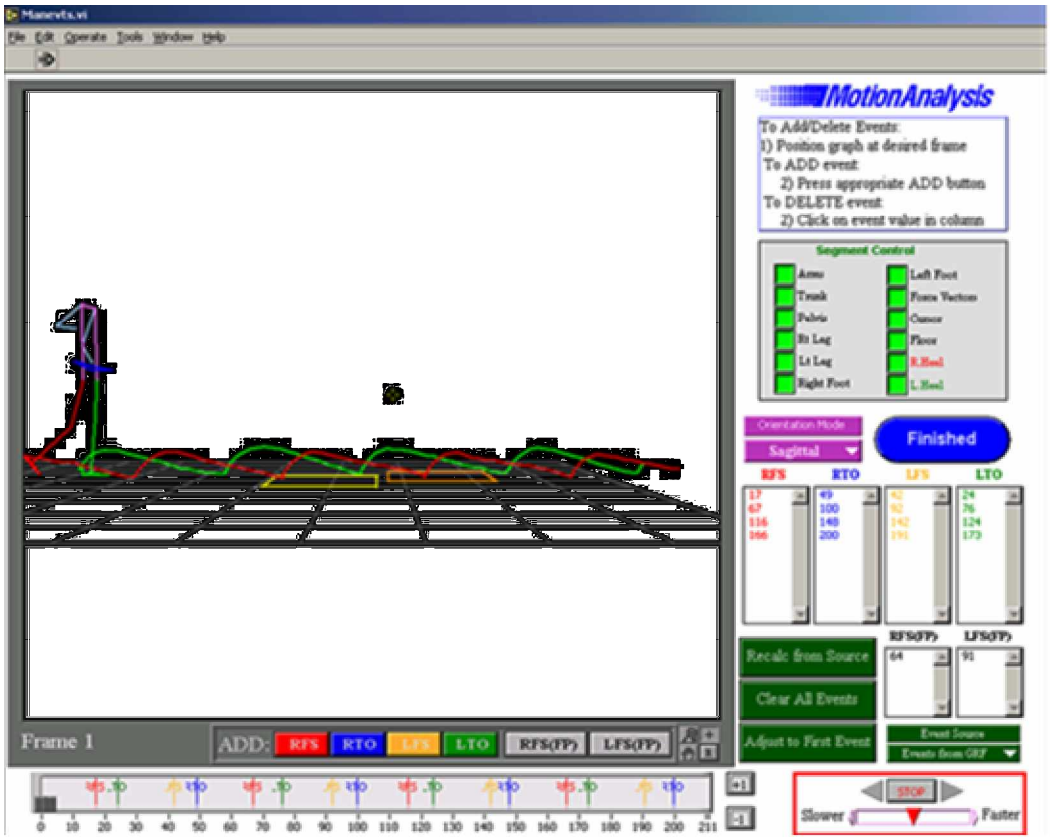

Figure 2.4 OrthoTrak Software System (Motion Analysis Corp.) automatically calculates the phases of the gait.

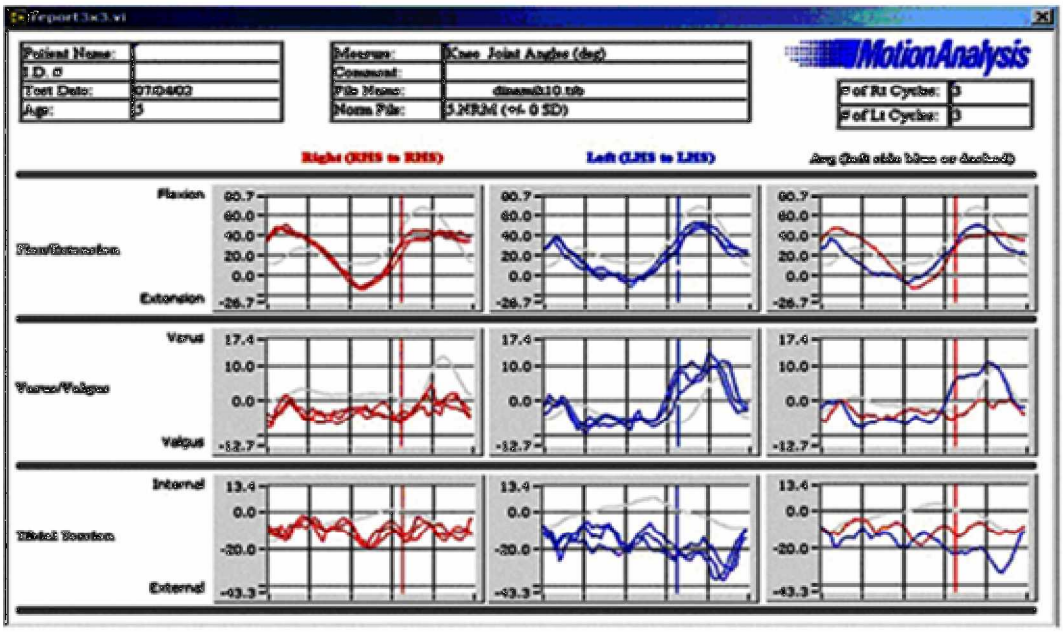

Figure 2.5 An example of the graphical output of kinematics and kinetic data in OrthoTrak Software System (Motion Analysis Corp.).

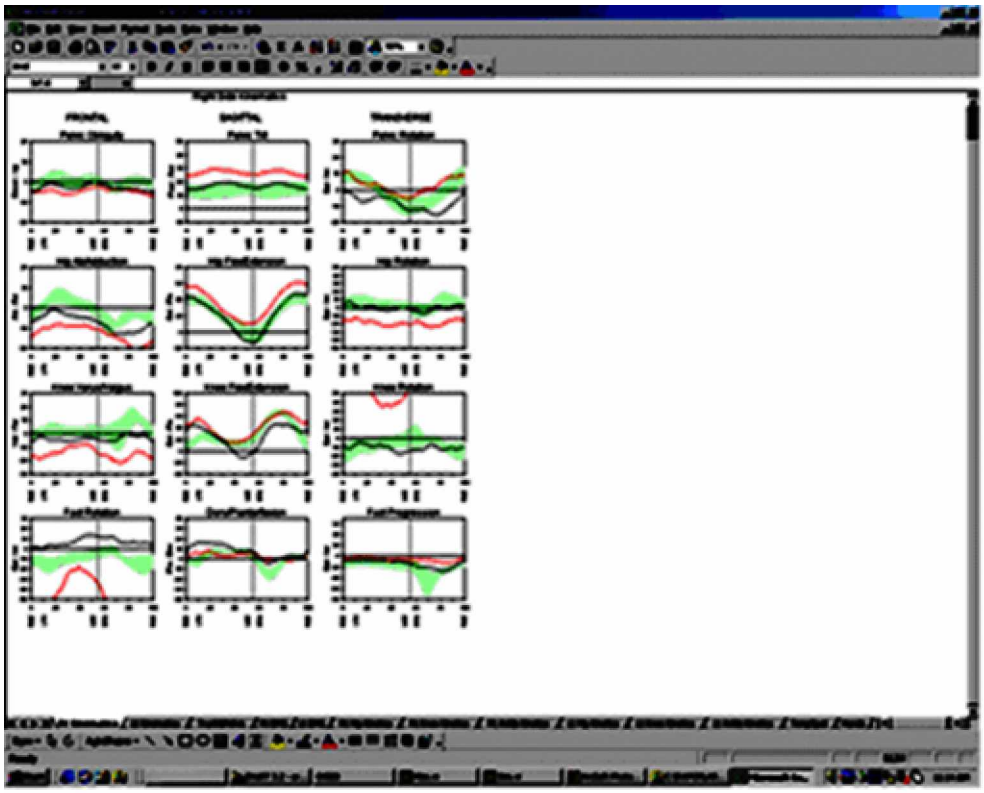

Figure 2.6 An example of the final outputs of OrthoTrak Software System (Motion Analysis Corp.).

2.2 Subjects

This study included nine age groups (ages of four, five, seven, eight, sixteen, seventeen, eighteen, and twenty). Exclusion criteria were (a) a history of any metabolic disease, (b) a history of any genetic disease (c) a history of any neuromuscular dysfunction, and (d) a history of any musculoskeletal injuries with loss of range within the last year. The total number of subjects included was one hundred and eighty-one: Ten females and ten males in each age group (only the number of eighteen-year-old males was eleven).

The purpose of the study and procedures to be used were explained to the subjects and informed consent was obtained.

In order to collect the anthropometric data, the subjects' height, weight, feet lengths and widths were measured.

Three-dimensional kinematics were recorded using EVa HIRES eight-camera system (Motion Analysis Corp., Eva HiRes with Falcon cameras, 60 Hz). The data of two force platforms (AMTI force plates, Advanced Mechanical Technology Inc., 1200 Hz) embedded into an eight and a half meters walkway were used to collect kinetic data. Subjects had retroreflective markers with adhesive backing placed on the upper and lower extremities bilaterally. Subjects were asked to walk barefoot and they had to perform ten successful crossings over the force platforms at self-selected walking speed. Orthotrak software (Motion Analysis Corporation) was used to calculate spatiotemporal, kinematics and kinetic data.

3. RESULTS

3.1 Basic Gait Parameters

The normal subjects were divided into groups according to age and sex. Basic gait parameters were calculated for these groups. In order to exemplify the results attained, mean, standard deviation, and range for each parameter for four-year-old age group are presented in Table 3.1. For other age groups, the results are presented in Appendix A.

Table 3.1 Basic Gait Parameters of 4-year-old Subjects
(SD: Standard Deviation, 'R' stands for right side, 'L' stands for left side, 'Dbl' stands for double.)

	Females				**Males**			
	Mean	SD	Mean+SD	Mean–SD	Mean	SD	Mean+SD	Mean–SD
Step Width (cm)	8.95	2.59	11.54	6.36	8.09	1.36	9.45	6.74
R_Velocity (cm/s)	105.64	12.35	117.98	93.29	101.71	13.19	114.90	88.52
R_Stride Length (cm)	84.69	7.72	92.41	76.97	82.07	6.79	88.86	75.28
R_Cadence (steps/min)	151.11	17.79	168.89	133.32	148.62	16.24	164.86	132.37
L_Velocity (cm/s)	105.60	12.26	117.86	93.34	102.07	13.81	115.88	88.26
L_Stride Length (cm)	84.94	7.59	92.53	77.35	81.17	7.17	88.33	74.00
L_Cadence (steps/min)	149.73	17.74	167.46	131.99	150.59	16.07	166.66	134.52
R_Stance Phase (%)	61.94	5.01	66.96	56.93	61.15	2.29	63.45	58.86
L_Stance Phase (%)	60.59	1.41	62.00	59.18	61.79	2.78	64.57	59.01
R_Swing Phase (%)	38.06	5.01	43.07	33.04	38.85	2.29	41.14	36.55
L_Swing Phase (%)	39.41	1.41	40.82	38.00	38.21	2.78	40.99	35.43
R_Step_Length (cm)	42.18	4.17	46.36	38.01	41.24	3.97	45.22	37.27
L_Step_Length (cm)	42.42	4.50	46.92	37.92	40.25	3.17	43.42	37.07
R_Dbl_Support Time (%)	12.37	4.89	17.26	7.48	11.34	2.23	13.57	9.10
L_Dbl_Support Time (%)	10.43	1.25	11.68	9.18	10.99	2.40	13.38	8.59
Right Heel Strike (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Left Heel Strike (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right Toe Off (%)	61.94	5.01	66.96	56.93	61.15	2.29	63.45	58.86
Left Toe Off (%)	60.59	1.41	62.00	59.18	61.79	2.78	64.57	59.01

Mean step width is found to be larger in males for each age, except for four-year-old subjects. This difference in step width between sexes increases as the age increases. Additionally, step width increases as the age increases.

Four-year-old subjects walked slower than the other age groups. As it can be expected, as the age increases, the step lengths increase, and cadence decreases.

In the literature, one complete gait cycle is shown to last for about one second in duration with sixty percent of stance and forty percent of swing periods on the average [20, 21, 22, 23, 24]. In this study, swing phases were usually less than forty percent of gait cycle. These durations vary with the speed of walking: The swing phase becomes proportionally shorter as the walking velocity decreases. In contrast, the stance and double support phases become longer [20]. Therefore, it can be inferred that our subjects walked slower than expected.

3.2 Kinematics

The kinematics data of females and males of the nine ages considered were examined separately. Kinematics data included the angles of hip, knee, and ankle joints of both lower extremities in all three planes or as movements of abduction/adduction, flexion/extension and rotation. Elbow, shoulder, trunk, pelvis, and foot movements were also examined in the same way. Mean, standard deviations, and ranges were calculated for each parameter at foot strike and toe off, for maximum and minimum values in stance and swing phases and for the times of the maximum and minimum values. The tables of four-year-old age group are presented in this section, and of other age groups in Appendix B.

The figures for each age group show the kinematics data plotted as graphs. The curves for females and males in each age group were plotted separately (males as dashed lines for separation) in the same graph with a gray band representing the gait analysis system's current normal band. This band has one standard deviation. Additionally, kinematics data of four-year-old age group were shown in a more detailed way: Curves for four-year-old females and males were shown in separate graphs, and in the same graph, again with a current normal band with one standard deviation. The figures for the four-year-old age group are presented in this section, and those of other age groups, in Appendix B.

For better understanding of the figures, it is useful to state that:

- x-axis represents 0-100 % of the gait cycle.
- The gray bands represent norm data of Orthotrak software (Motion Analysis Corp.) with one standard deviation.
- RHS = Right Heel Strike and LHS = Left Heel Strike.

Table 3.2 Stance Phase Kinematics of 4-year-old Female Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Foot Strike		**Maximum Stance**		**Time of Max. St.**		**Minimum Stance**		**Time of Min. St.**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-8.10	5.82	5.62	6.21	27.90	14.26	-8.10	5.82	0.00	0.00
L_Hip_Rot_Ang	-6.02	8.19	5.74	8.98	18.70	2.00	-6.67	8.08	23.30	30.10
R_Hip_Abd_Ang	2.09	2.09	11.27	3.00	20.90	2.13	-2.15	4.20	48.40	25.62
L_Hip_Abd_Ang	0.47	2.10	6.69	1.96	17.90	1.97	-8.24	2.38	59.70	1.57
R_Hip_Flex_Ang	35.46	5.74	35.46	5.74	0.00	0.00	-11.72	6.47	52.40	1.43
L_Hip_Flex_Ang	35.62	6.45	35.62	6.45	0.00	0.00	-12.35	6.50	51.80	1.93
R_Knee_Rot_Ang	4.95	11.29	13.47	15.41	35.80	27.41	-1.61	11.87	33.10	23.75
L_Knee_Rot_Ang	10.68	14.62	23.01	15.41	53.30	15.38	5.94	15.07	19.50	20.53
R_Knee_Abd_Ang	-4.73	1.47	-0.36	3.51	36.50	21.46	-5.54	2.14	31.60	27.80
L_Knee_Abd_Ang	-5.44	2.37	-1.62	3.38	25.50	18.50	-6.74	3.13	32.50	27.99
R_Knee_Flex_Ang	12.88	5.53	35.91	10.89	56.70	15.44	3.84	5.86	33.20	17.74
L_Knee_Flex_Ang	13.82	7.77	35.92	3.04	59.70	1.57	4.23	6.15	35.90	12.71
R_Ank_Rot_Ang	-15.20	8.05	-7.15	7.92	38.40	20.59	-29.05	11.16	19.40	20.20
L_Ank_Rot_Ang	-19.29	13.70	-11.32	8.92	30.90	21.47	-32.65	14.36	18.90	14.53
R_Ank_Abd_Ang	-2.03	1.74	0.14	0.97	50.40	19.03	-6.60	3.07	26.20	18.28
L_Ank_Abd_Ang	-3.39	3.52	-0.80	1.67	53.40	18.81	-8.10	5.83	22.40	8.09
R_Ank_Flex_Ang	5.10	4.19	15.11	4.03	36.80	6.97	-1.88	4.25	53.80	18.97
L_Ank_Flex_Ang	6.53	3.55	15.98	3.10	37.30	6.99	0.63	4.19	53.50	18.85
R_Elbow_Ang	43.40	25.90	57.37	21.60	49.80	6.25	42.06	25.78	8.50	3.06
L_Elbow_Ang	39.40	19.60	53.70	16.14	51.20	4.71	37.87	20.01	7.50	3.92
R_Shl_Add_Ang	30.08	9.09	30.27	8.98	10.10	20.88	22.27	7.60	35.00	14.84
L_Shl_Add_Ang	27.62	5.07	27.95	5.16	6.70	15.69	20.41	5.20	36.90	13.40
R_Shl_Flex_Ang	-64.42	11.96	-22.87	28.16	47.40	6.08	-64.87	11.83	1.80	2.15
L_Shl_Flex_Ang	-62.38	12.04	-9.22	13.65	49.50	1.08	-62.95	11.74	3.90	2.73
R_Trunk_Lat_Tilt	-0.52	1.74	1.45	2.26	55.50	10.14	-0.99	1.80	16.80	13.53
L_Trunk_Lat_Tilt	-0.52	1.74	1.44	2.26	55.40	10.13	-0.99	1.80	16.80	13.53
R_Trunk_Fwd_Tilt	-0.92	2.87	0.14	3.30	32.00	17.19	-3.24	3.34	41.80	24.03
L_Trunk_Fwd_Tilt	-0.92	2.87	0.14	3.30	32.00	17.19	-3.19	3.29	41.20	23.47
R_Trunk_Rotation	1.57	4.23	8.60	2.47	47.00	8.21	1.05	3.74	6.00	6.34
L_Trunk_Rotation	1.57	4.23	8.60	2.47	47.00	8.21	1.05	3.74	6.00	6.34
R_Pelvis_Lat_Tilt	3.61	1.76	7.05	1.64	16.00	1.94	-1.75	1.98	59.90	1.66
L_Pelvis_Lat_Tilt	3.61	1.76	7.05	1.64	16.00	1.94	-1.73	1.87	59.70	1.57
R_Pelvis_Fwd_Tilt	10.31	4.67	11.60	4.93	42.90	6.62	8.79	4.57	28.50	21.15
L_Pelvis_Fwd_Tilt	10.31	4.67	11.60	4.93	42.90	6.62	8.81	4.55	28.40	21.00
R_Pelvis_Rotation	10.01	2.30	10.48	2.06	5.80	4.21	-2.09	3.57	56.20	3.68
L_Pelvis_Rotation	10.01	2.30	10.48	2.06	5.80	4.21	-2.11	3.56	56.40	3.95
R_Foot_Orientation	-6.97	4.28	-2.45	5.17	17.30	2.45	-8.62	5.20	36.70	32.01
L_Foot_Orientation	-12.95	4.29	-7.96	4.80	28.50	18.16	-13.96	5.18	20.80	27.96

Table 3.3 Swing Phase Kinematics of 4-year-old Female Subjects
(Max = Maximum, Sw. = Swing, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Maximum Swing		**Time of Max. Sw.**		**Minimum Swing**		**Time of Min. Sw.**		**Toe Off**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	1.08	5.48	71.34	11.07	-8.81	5.63	93.94	10.16	-0.29	6.36
L_Hip_Rot_Ang	2.61	7.49	77.99	9.67	-7.11	8.03	87.39	18.31	-2.18	9.94
R_Hip_Abd_Ang	1.48	2.37	95.94	6.24	-4.26	3.68	68.54	3.45	-2.34	4.21
L_Hip_Abd_Ang	-0.13	1.90	98.89	0.26	-9.90	2.34	65.59	1.58	-8.69	2.38
R_Hip_Flex_Ang	37.61	5.23	92.84	2.82	-3.29	12.53	61.94	5.01	-3.29	12.53
L_Hip_Flex_Ang	38.45	5.82	91.79	2.95	-5.43	6.26	60.59	1.41	-5.43	6.26
R_Knee_Rot_Ang	23.97	14.53	74.14	2.90	1.95	12.37	91.14	11.93	12.25	16.96
L_Knee_Rot_Ang	31.74	15.69	70.19	4.04	9.11	11.08	96.69	3.45	23.73	14.98
R_Knee_Abd_Ang	4.02	4.20	80.44	5.47	-5.01	2.88	91.04	14.25	-1.49	4.39
L_Knee_Abd_Ang	2.03	6.20	80.39	7.99	-8.05	4.95	80.39	15.18	-4.68	5.84
R_Knee_Flex_Ang	67.17	5.35	74.34	0.97	13.35	5.85	98.94	0.21	38.58	9.95
L_Knee_Flex_Ang	71.77	5.74	74.09	1.13	14.55	7.05	98.89	0.26	39.36	2.98
R_Ank_Rot_Ang	-13.53	9.32	91.04	16.25	-35.94	12.37	77.44	2.56	-19.70	13.56
L_Ank_Rot_Ang	-19.09	12.30	98.09	1.76	-40.84	13.87	77.29	2.27	-25.73	11.02
R_Ank_Abd_Ang	0.78	2.16	74.84	16.02	-5.35	3.00	81.94	1.79	-0.33	3.00
L_Ank_Abd_Ang	-0.06	2.32	66.79	11.66	-7.53	4.24	83.09	1.58	-0.67	1.81
R_Ank_Flex_Ang	8.23	3.27	88.04	5.33	-2.88	5.91	70.14	15.22	-1.87	5.70
L_Ank_Flex_Ang	9.40	2.85	88.89	4.06	-1.18	4.73	64.09	1.80	0.01	4.40
R_Elbow_Ang	55.48	22.50	67.94	13.09	44.34	27.10	92.34	13.96	54.97	22.81
L_Elbow_Ang	51.26	17.19	64.59	8.68	39.57	20.21	96.89	6.17	51.22	17.18
R_Shl_Add_Ang	30.42	8.52	93.34	11.44	23.25	7.66	69.24	7.05	24.75	7.68
L_Shl_Add_Ang	27.66	5.04	94.19	11.88	20.69	4.51	68.99	6.61	21.90	5.16
R_Shl_Flex_Ang	-31.62	27.71	61.94	5.01	-64.21	12.94	95.84	7.14	-31.62	27.71
L_Shl_Flex_Ang	-18.53	14.39	60.59	1.41	-61.19	11.35	98.89	0.26	-18.53	14.39
R_Trunk_Lat_Tilt	1.42	2.41	68.54	11.68	-0.45	1.88	96.54	7.57	1.30	2.36
L_Trunk_Lat_Tilt	1.50	2.42	66.99	11.51	-0.45	1.88	96.49	7.67	1.38	2.38
R_Trunk_Fwd_Tilt	0.05	3.17	91.14	2.46	-3.06	3.25	65.34	4.30	-2.85	3.25
L_Trunk_Fwd_Tilt	0.05	3.17	91.09	2.48	-3.16	3.33	64.19	2.11	-2.94	3.32
R_Trunk_Rotation	7.31	3.28	61.94	5.01	1.31	4.88	89.44	6.58	7.31	3.28
L_Trunk_Rotation	7.51	3.09	60.59	1.41	1.31	4.88	89.39	6.67	7.51	3.09
R_Pelvis_Lat_Tilt	3.43	1.53	97.84	3.37	-2.22	2.00	66.84	3.54	-1.64	2.08
L_Pelvis_Lat_Tilt	3.43	1.53	97.79	3.40	-2.51	1.77	65.59	1.66	-1.92	1.86
R_Pelvis_Fwd_Tilt	11.03	4.55	90.44	6.85	9.18	4.66	71.14	10.85	9.60	4.68
L_Pelvis_Fwd_Tilt	11.08	4.57	88.99	10.63	9.18	4.66	71.09	10.61	9.66	4.67
R_Pelvis_Rotation	10.04	3.05	98.94	0.21	-1.56	3.71	63.04	5.09	-1.50	3.72
L_Pelvis_Rotation	10.04	3.05	98.89	0.26	-1.87	3.55	61.49	2.36	-1.82	3.56
R_Foot_Orientation	-6.94	5.18	84.74	18.70	-16.26	6.82	82.34	3.92	-8.47	5.85
L_Foot_Orientation	-10.34	5.05	69.49	15.68	-20.96	4.36	83.79	4.07	-11.09	6.15

Table 3.4 Stance Phase Kinematics of 4-year-old Male Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Foot Strike		**Maximum Stance**		**Time of Max. St.**		**Minimum Stance**		**Time of Min. St.**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-6.86	6.56	5.93	10.77	41.60	16.73	-6.86	6.56	0.00	0.00
L_Hip_Rot_Ang	-10.72	11.44	2.24	13.99	30.40	16.37	-10.96	11.44	4.80	15.18
R_Hip_Abd_Ang	0.55	2.91	8.49	2.62	20.30	2.75	-4.44	2.98	54.20	19.18
L_Hip_Abd_Ang	1.31	4.23	8.42	3.26	19.10	3.84	-5.87	3.01	60.80	2.78
R_Hip_Flex_Ang	31.62	7.09	31.62	7.09	0.00	0.00	-13.85	6.44	52.90	2.33
L_Hip_Flex_Ang	33.29	6.99	33.29	6.99	0.00	0.00	-11.73	7.11	52.30	2.75
R_Knee_Rot_Ang	0.79	10.66	11.55	10.30	39.60	25.74	-4.85	9.20	22.80	24.29
L_Knee_Rot_Ang	4.84	18.11	18.79	17.45	46.10	22.98	0.71	18.66	26.20	20.08
R_Knee_Abd_Ang	-3.02	1.92	1.40	3.34	45.80	21.00	-3.70	1.68	21.70	22.11
L_Knee_Abd_Ang	-3.96	2.67	-0.37	4.00	41.50	18.42	-6.77	4.30	43.70	23.07
R_Knee_Flex_Ang	5.02	7.01	30.62	5.53	60.10	2.33	0.06	4.34	29.70	18.98
L_Knee_Flex_Ang	5.37	5.10	35.88	8.49	60.80	2.78	1.32	4.57	31.60	17.02
R_Ank_Rot_Ang	-11.19	10.07	-5.01	8.41	36.70	19.59	-24.98	12.05	22.50	19.03
L_Ank_Rot_Ang	-6.93	8.35	-0.57	6.73	36.40	19.47	-20.67	10.95	22.70	19.42
R_Ank_Abd_Ang	-1.58	1.20	0.67	1.34	57.10	7.26	-4.44	2.40	18.90	2.73
L_Ank_Abd_Ang	-1.16	1.17	0.34	0.77	52.20	10.91	-3.68	2.40	22.20	13.38
R_Ank_Flex_Ang	4.75	4.09	15.47	2.84	39.40	9.49	-1.73	3.15	48.70	24.73
L_Ank_Flex_Ang	3.86	3.92	15.20	4.05	40.20	7.98	-1.46	4.14	49.50	24.91
R_Elbow_Ang	29.52	7.92	49.48	7.44	50.10	2.64	28.50	7.44	5.80	2.49
L_Elbow_Ang	32.00	7.62	50.52	9.64	50.70	2.98	30.34	7.09	7.30	3.13
R_Shl_Add_Ang	25.90	4.48	26.19	4.19	10.40	21.41	18.31	2.48	37.80	16.80
L_Shl_Add_Ang	28.65	5.65	28.81	5.59	6.30	17.86	22.71	5.31	34.40	8.36
R_Shl_Flex_Ang	-62.44	13.16	-9.42	16.25	49.30	2.98	-63.14	13.37	3.80	4.54
L_Shl_Flex_Ang	-66.61	10.39	-22.37	16.03	49.80	2.49	-67.10	10.23	4.60	3.20
R_Trunk_Lat_Tilt	-0.70	1.60	1.84	1.33	58.70	5.12	-1.31	1.94	11.90	4.58
L_Trunk_Lat_Tilt	-0.70	1.60	1.86	1.29	59.20	5.51	-1.31	1.94	11.90	4.58
R_Trunk_Fwd_Tilt	-2.91	3.54	-1.60	3.87	35.30	12.51	-5.19	3.86	41.30	25.09
L_Trunk_Fwd_Tilt	-2.91	3.54	-1.60	3.87	35.30	12.51	-5.20	3.80	46.30	23.75
R_Trunk_Rotation	-0.63	5.39	4.30	5.00	45.00	14.17	-0.97	5.27	14.40	22.27
L_Trunk_Rotation	-0.63	5.39	4.30	5.00	44.90	14.05	-0.97	5.27	14.40	22.27
R_Pelvis_Lat_Tilt	1.81	2.14	5.02	2.04	15.40	2.50	-3.41	2.34	60.10	2.33
L_Pelvis_Lat_Tilt	1.81	2.14	5.02	2.04	15.40	2.50	-3.61	2.15	60.80	2.78
R_Pelvis_Fwd_Tilt	10.54	4.40	11.33	4.30	40.20	14.32	8.31	4.13	33.40	23.85
L_Pelvis_Fwd_Tilt	10.54	4.40	11.33	4.30	40.20	14.32	8.29	4.11	33.50	23.95
R_Pelvis_Rotation	9.45	3.20	10.42	2.77	8.80	5.43	-3.71	3.76	57.80	4.71
L_Pelvis_Rotation	9.45	3.20	10.42	2.77	8.80	5.43	-3.76	3.84	58.20	5.20
R_Foot_Orientation	-7.69	4.78	-2.51	6.21	20.20	13.40	-9.23	6.01	34.90	30.04
L_Foot_Orientation	-10.01	5.90	-3.66	6.14	25.80	18.62	-10.31	6.07	21.20	27.66

Table 3.5 Swing Phase Kinematics of 4-year-old Male Subjects
(Max = Maximum, Sw. = Swing, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Maximum Swing		**Time of Max. Sw.**		**Minimum Swing**		**Time of Min. Sw.**		**Toe Off**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	3.53	8.92	69.55	9.96	-7.47	6.33	98.05	1.92	2.65	9.77
L_Hip_Rot_Ang	-0.71	11.61	69.69	9.20	-11.71	11.15	94.49	10.25	-2.68	11.67
R_Hip_Abd_Ang	-0.20	2.37	93.65	12.78	-6.84	2.60	68.25	3.37	-4.79	3.11
L_Hip_Abd_Ang	0.74	4.13	98.99	0.30	-7.39	2.55	66.89	3.38	-6.27	2.94
R_Hip_Flex_Ang	35.31	7.43	89.75	2.48	-7.50	6.01	61.15	2.29	-7.50	6.01
L_Hip_Flex_Ang	36.50	6.53	89.79	2.65	-3.38	7.95	61.79	2.78	-3.38	7.95
R_Knee_Rot_Ang	27.62	15.17	74.35	2.29	-1.07	10.62	87.25	18.40	9.85	11.95
L_Knee_Rot_Ang	30.36	15.61	73.19	3.08	2.94	18.88	97.79	2.17	18.31	16.11
R_Knee_Abd_Ang	5.48	5.31	76.55	10.17	-3.35	2.23	92.05	12.88	0.88	4.20
L_Knee_Abd_Ang	0.96	7.66	88.29	7.52	-8.76	7.19	79.59	13.40	-4.51	7.37
R_Knee_Flex_Ang	68.92	5.12	74.95	1.29	5.90	7.63	99.05	0.33	34.21	5.64
L_Knee_Flex_Ang	70.72	4.02	74.79	1.76	5.97	5.45	98.99	0.30	39.50	8.51
R_Ank_Rot_Ang	-9.14	9.07	87.55	18.61	-39.82	13.41	77.45	1.17	-18.39	9.94
L_Ank_Rot_Ang	-5.48	7.99	94.89	12.76	-35.70	13.21	77.59	1.21	-15.73	10.70
R_Ank_Abd_Ang	1.31	1.73	68.25	9.87	-6.77	3.28	82.85	1.37	0.51	1.47
L_Ank_Abd_Ang	0.89	1.19	68.99	9.89	-5.81	3.54	84.29	5.42	0.01	0.83
R_Ank_Flex_Ang	9.28	2.43	88.15	3.20	-3.72	3.01	67.85	11.33	-1.60	4.06
L_Ank_Flex_Ang	8.37	4.62	86.49	4.17	-2.84	4.58	67.89	11.36	-1.35	4.78
R_Elbow_Ang	45.70	6.33	61.15	2.29	30.49	8.61	99.05	0.33	45.70	6.33
L_Elbow_Ang	46.73	8.42	61.79	2.78	33.07	8.85	98.99	0.30	46.73	8.42
R_Shl_Add_Ang	26.29	4.42	97.25	2.83	18.91	3.05	67.25	5.73	19.68	3.11
L_Shl_Add_Ang	29.08	5.06	98.39	1.39	23.47	5.18	68.19	6.90	24.22	5.41
R_Shl_Flex_Ang	-16.99	17.71	61.15	2.29	-60.89	13.53	98.85	0.60	-16.99	17.71
L_Shl_Flex_Ang	-30.91	18.54	61.79	2.78	-66.34	10.19	98.99	0.30	-30.91	18.54
R_Trunk_Lat_Tilt	1.88	1.29	63.55	3.45	-0.43	1.58	97.55	3.56	1.82	1.29
L_Trunk_Lat_Tilt	1.88	1.29	63.89	3.17	-0.43	1.58	97.49	3.65	1.83	1.25
R_Trunk_Fwd_Tilt	-2.01	3.74	90.05	2.23	-5.17	3.87	63.55	1.86	-4.99	3.91
L_Trunk_Fwd_Tilt	-2.01	3.74	89.99	2.32	-5.14	3.84	63.89	2.04	-5.01	3.84
R_Trunk_Rotation	2.93	5.15	69.55	15.75	-1.28	4.48	86.75	7.06	2.86	5.15
L_Trunk_Rotation	2.82	5.12	69.99	15.37	-1.28	4.48	86.69	7.05	2.79	5.13
R_Pelvis_Lat_Tilt	1.44	2.10	94.45	6.13	-4.33	2.31	66.05	3.08	-3.64	2.32
L_Pelvis_Lat_Tilt	1.44	2.10	94.39	6.09	-4.33	2.31	65.99	3.07	-3.81	2.18
R_Pelvis_Fwd_Tilt	10.97	4.62	92.55	4.54	8.76	4.17	66.05	2.12	9.11	4.31
L_Pelvis_Fwd_Tilt	10.97	4.62	92.49	4.59	8.76	4.17	65.99	2.20	9.04	4.27
R_Pelvis_Rotation	9.08	3.04	99.05	0.33	-3.55	3.89	62.05	3.16	-3.50	3.84
L_Pelvis_Rotation	9.08	3.04	98.99	0.30	-3.53	3.92	62.29	3.01	-3.51	3.93
R_Foot_Orientation	-7.78	5.51	84.75	18.44	-17.22	6.31	82.35	2.62	-8.71	6.32
L_Foot_Orientation	-6.80	5.96	66.49	11.64	-18.22	4.99	85.69	3.43	-6.92	6.03

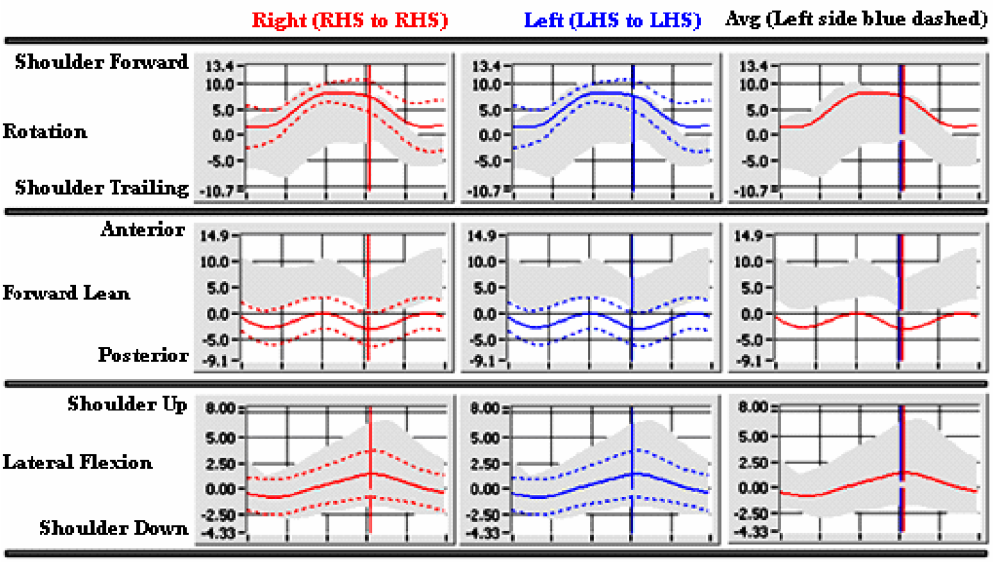

Figure 3.1 Trunk Orientation Relative to Room (Degrees), 4-year-old females.

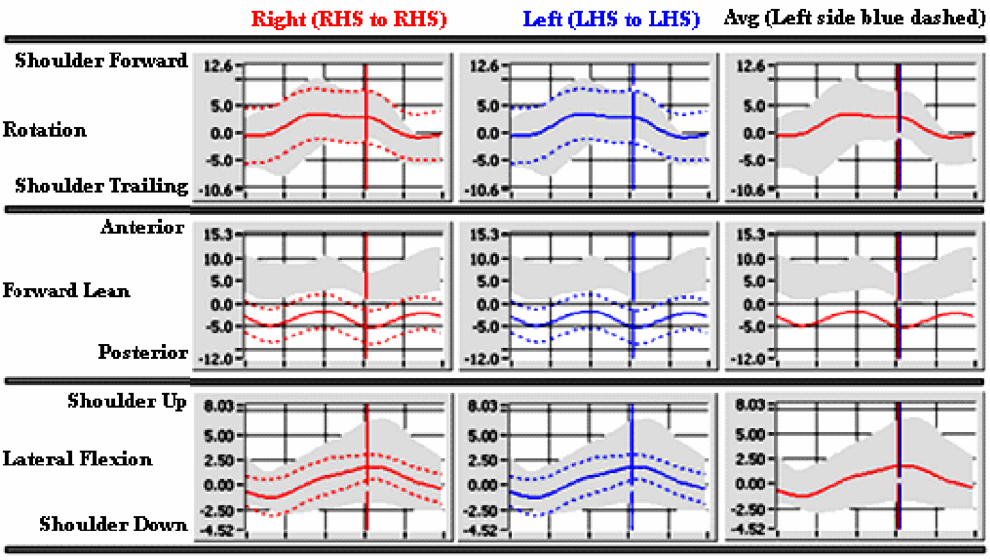

Figure 3.2 Trunk Orientation Relative to Room (Degrees), 4-year-old-males.

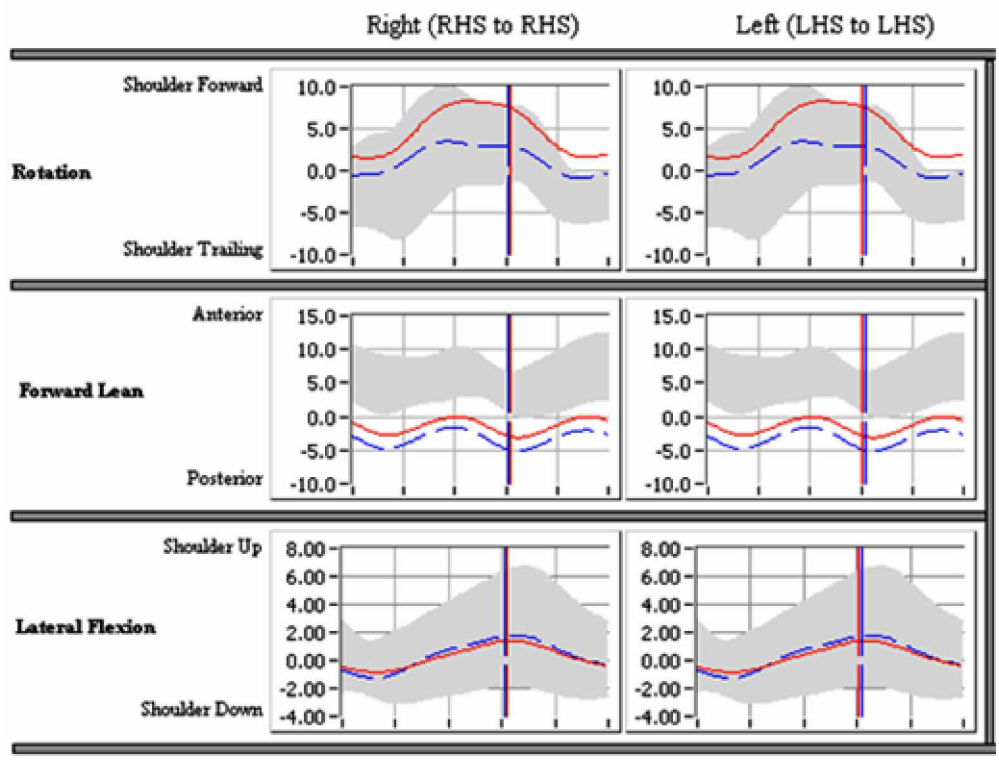

Figure 3.3 Trunk Orientation Relative to Room (Degrees), 4-year-old subjects.

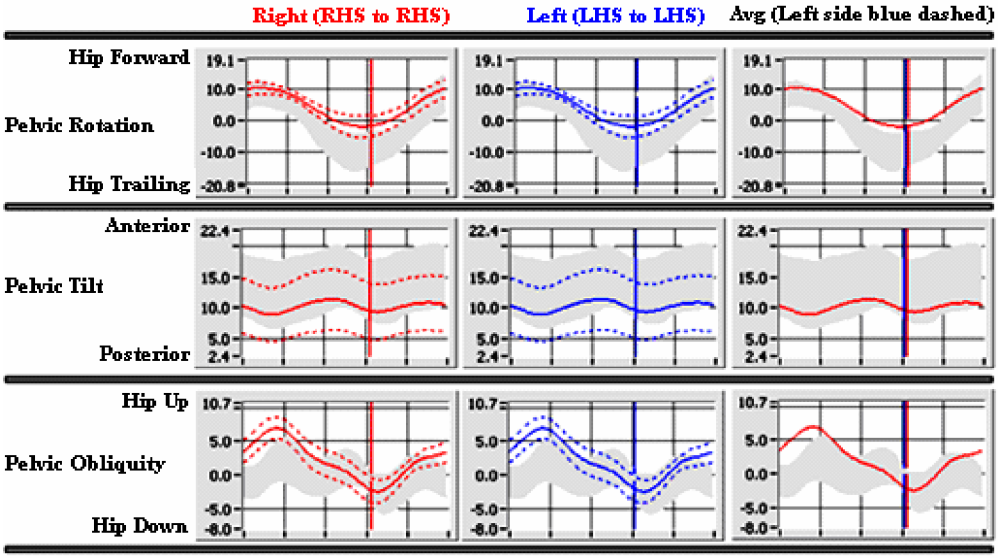

Figure 3.4 Pelvis Orientation Relative to Room (Degrees), 4-year-old females.

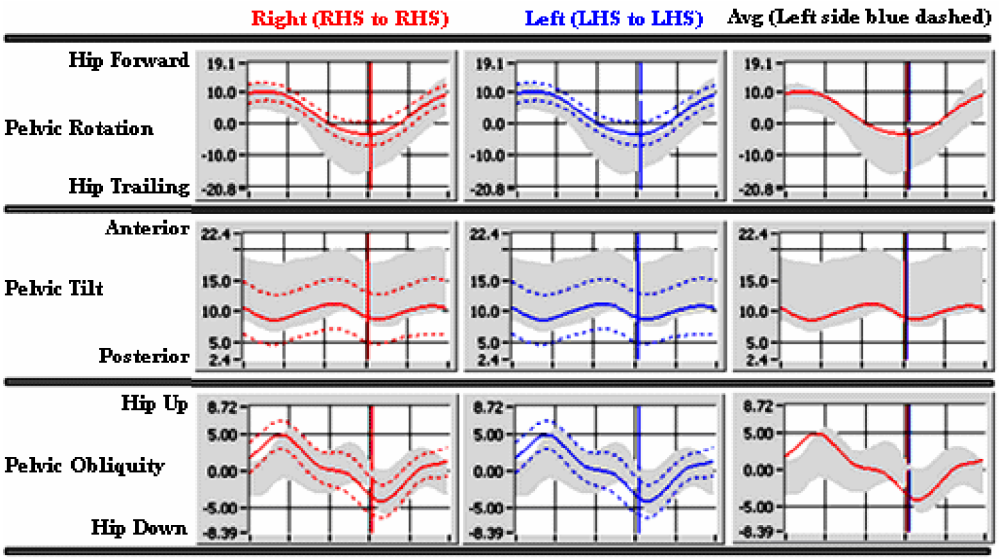

Figure 3.5 Pelvis Orientation Relative to Room (Degrees), 4-year-old-males.

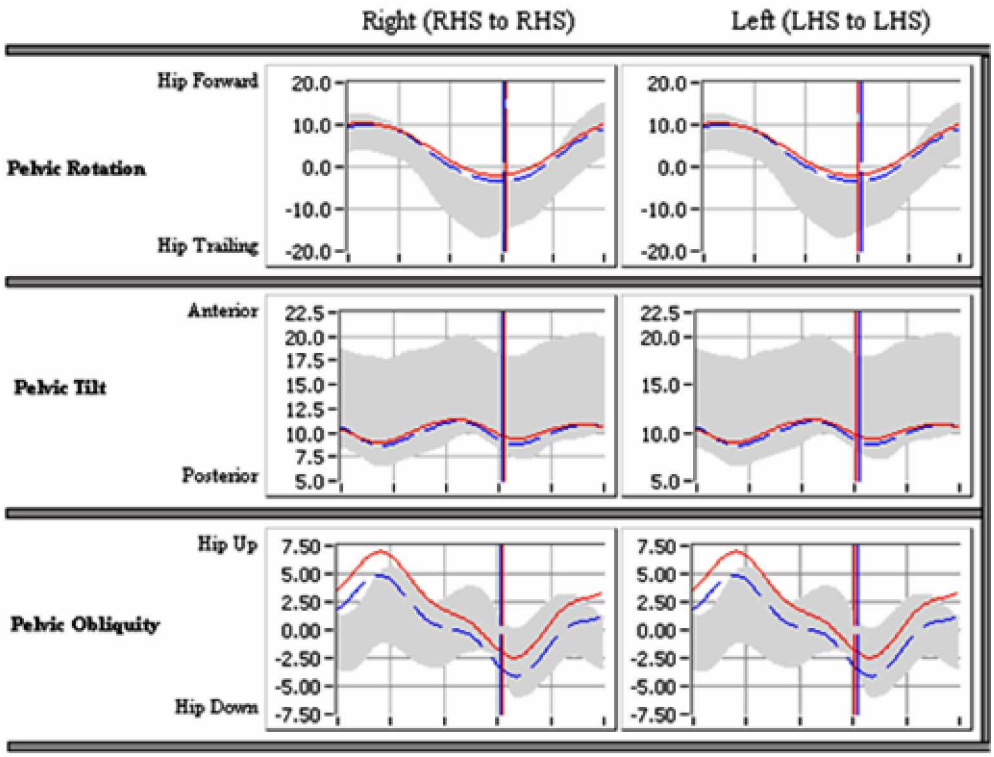

Figure 3.6 Pelvis Orientation Relative to Room (Degrees), 4-year-old subjects.

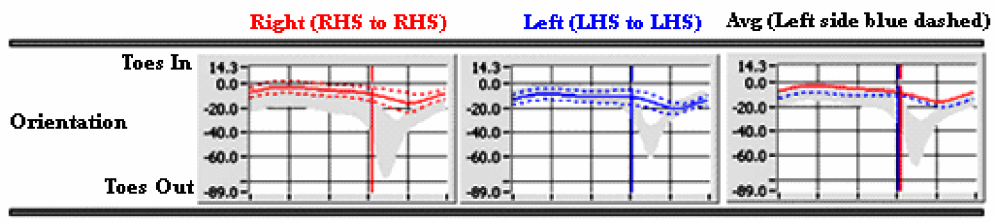

Figure 3.7 Foot Orientation Relative to Room (Degrees), 4-year-old females.

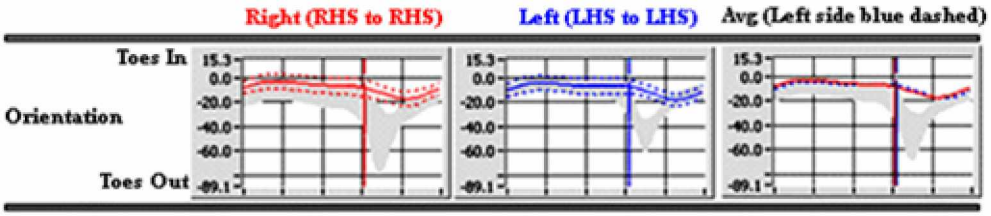

Figure 3.8 Foot Orientation Relative to Room (Degrees), 4-year-old males.

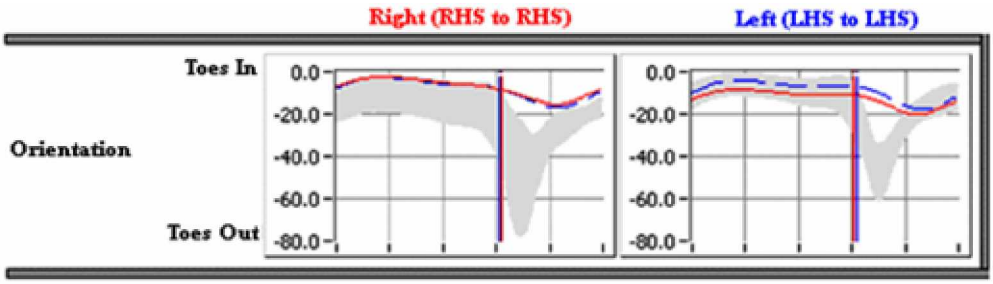

Figure 3.9 Foot Orientation Relative to Room (Degrees), 4-year-old subjects.

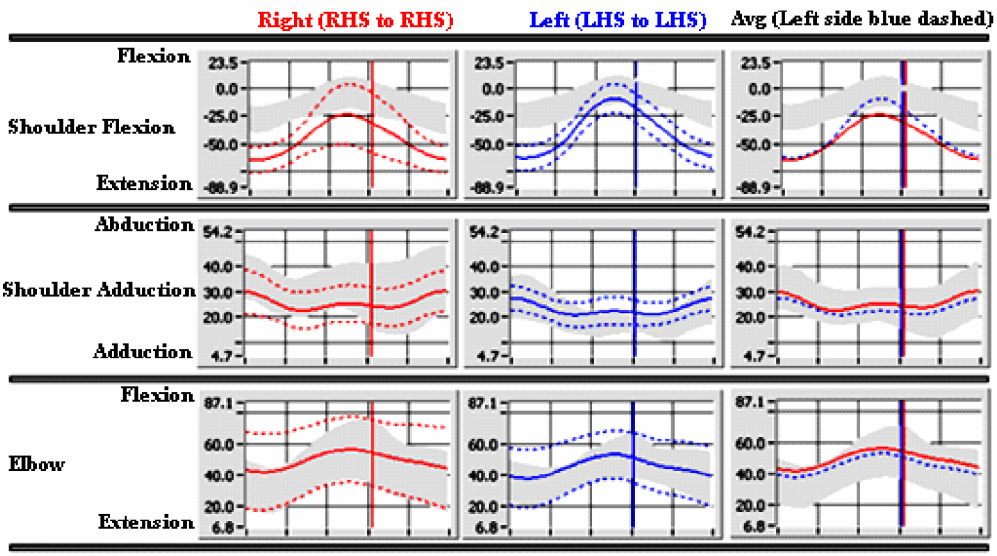

Figure 3.10 Arm Joint Angles (Degrees), 4-year-old females.

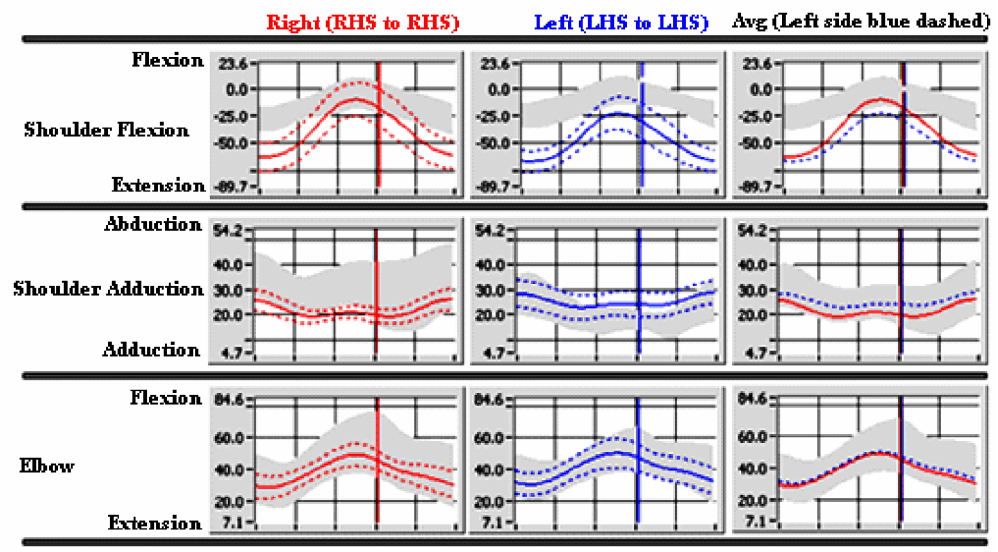

Figure 3.11 Arm Joint Angles (Degrees), 4-year-old males.

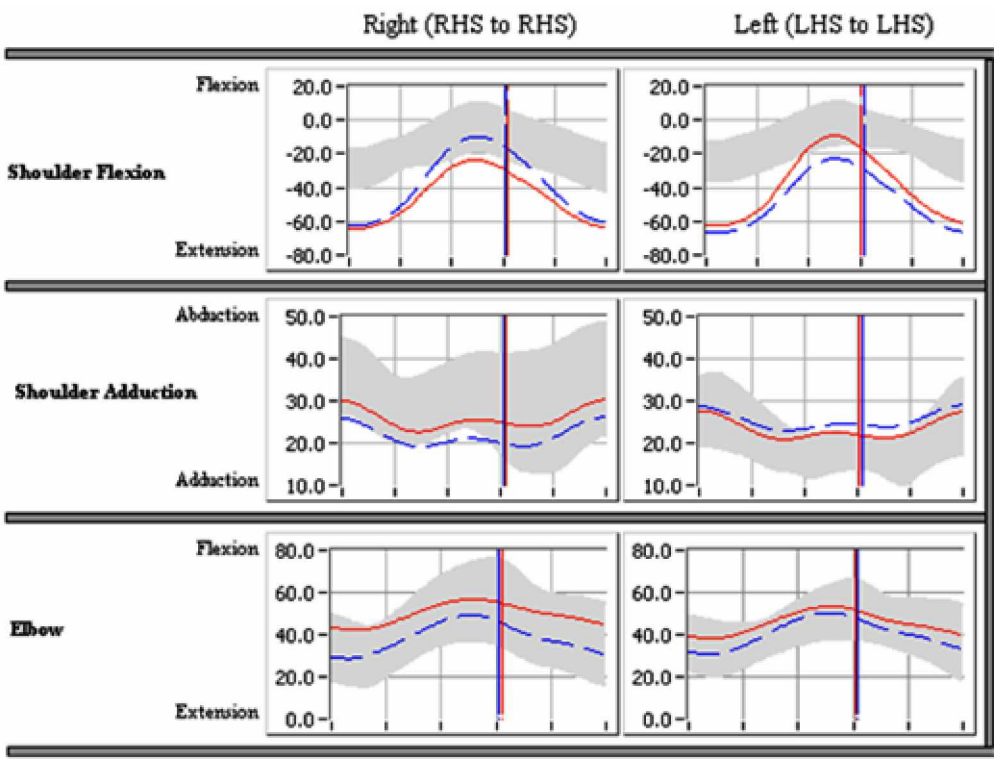

Figure 3.12 Arm Joint Angles (Degrees), 4-year-old subjects.

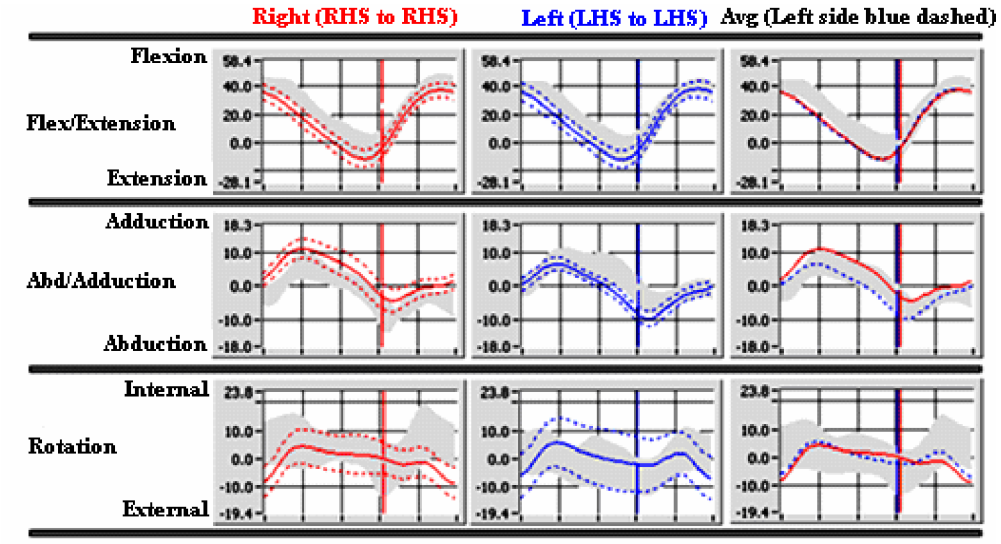

Figure 3.13 Hip Joint Angles (Degrees), 4-year-old females.

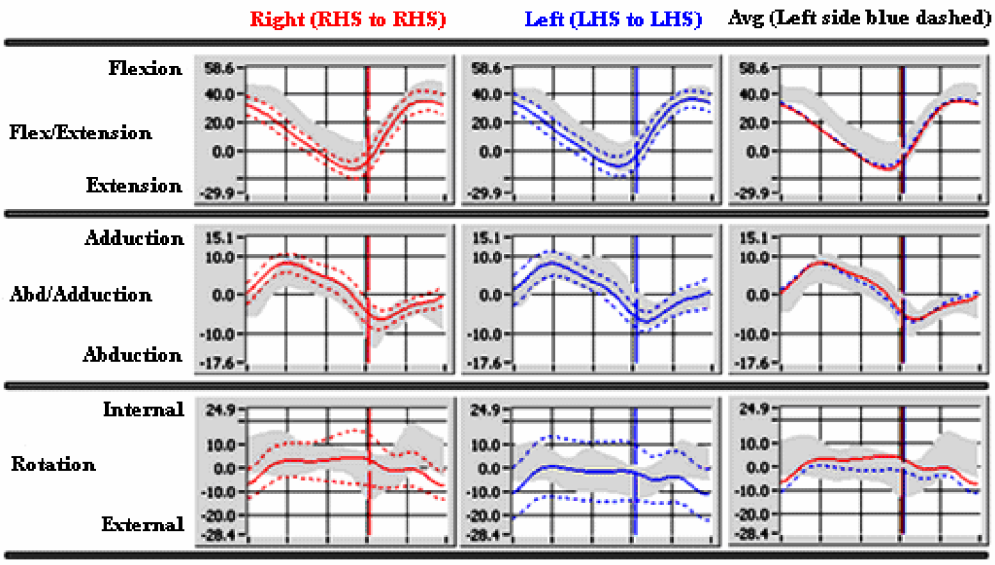

Figure 3.14 Hip Joint Angles (Degrees), 4-year-old males.

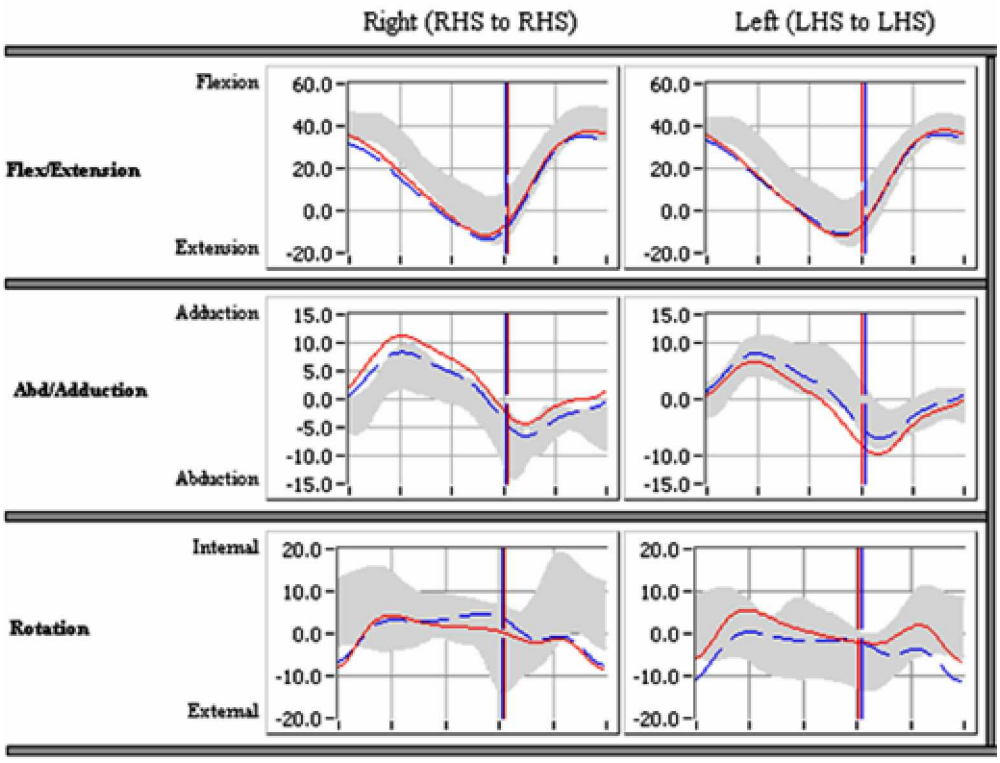

Figure 3.15 Hip Joint Angles (Degrees), 4-year-old subjects.

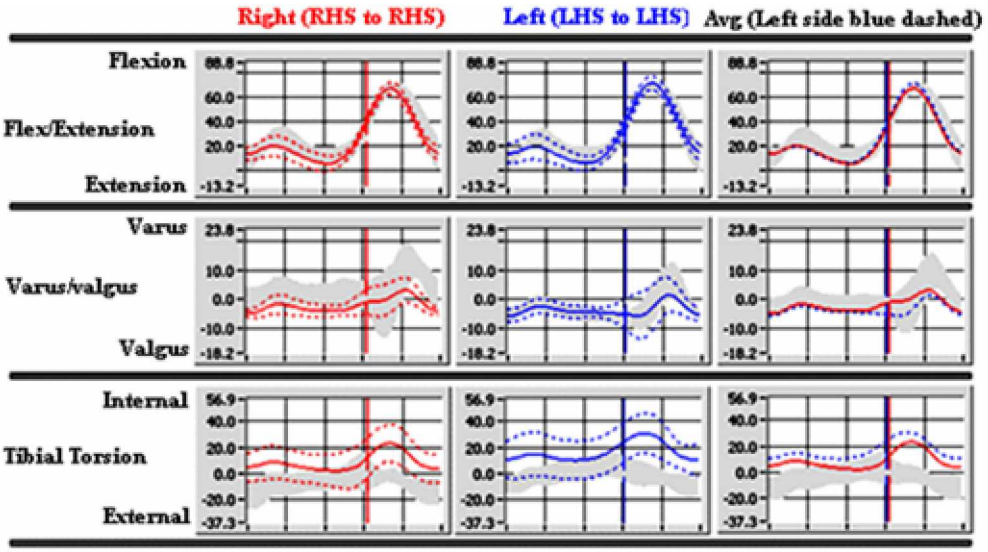

Figure 3.16 Knee Joint Angles (Degrees), 4-year-old females.

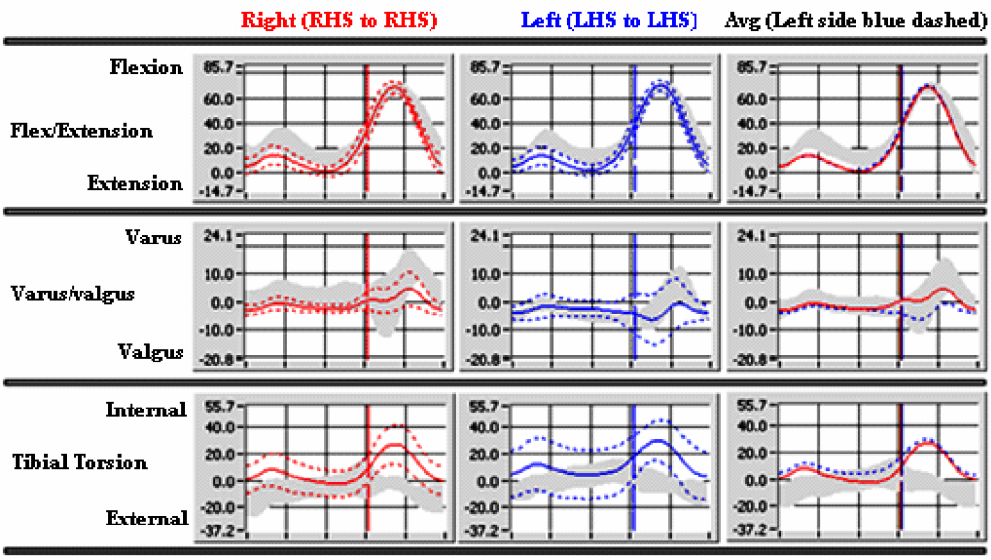

Figure 3.17 Knee Joint Angles (Degrees), 4-year-old males.

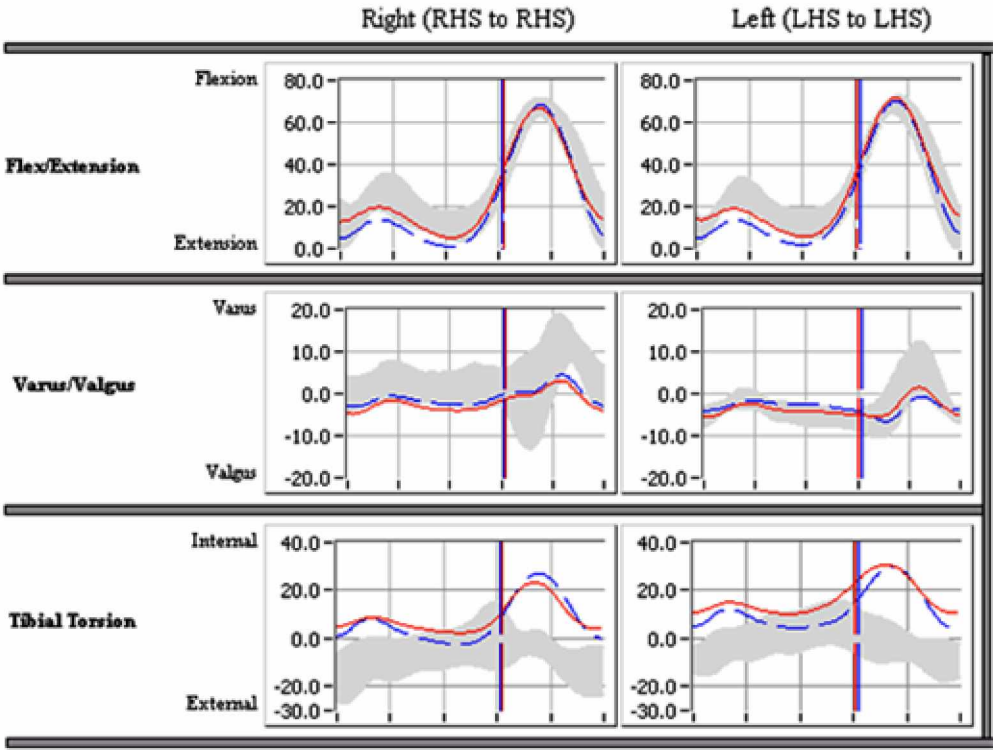

Figure 3.18 Knee Joint Angles (Degrees), 4-year-old subjects.

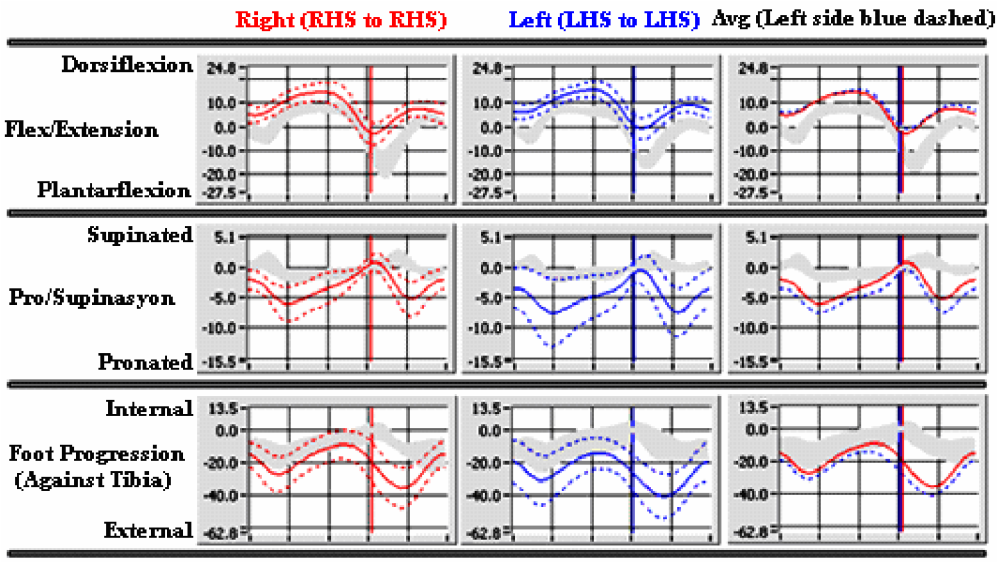

Figure 3.19 Ankle Joint Angles (Degrees), 4-year-old females.

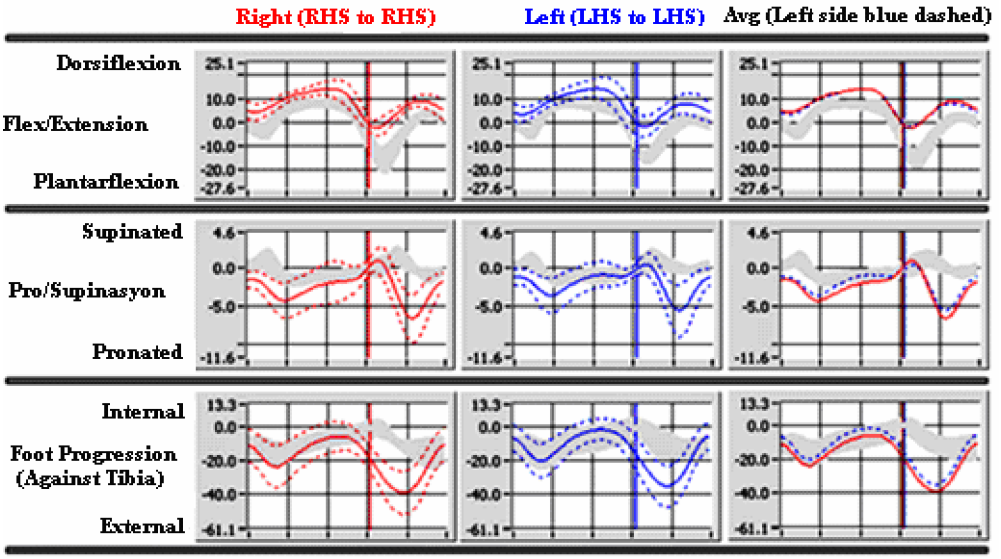

Figure 3.20 Ankle Joint Angles (Degrees), 4-year-old males.

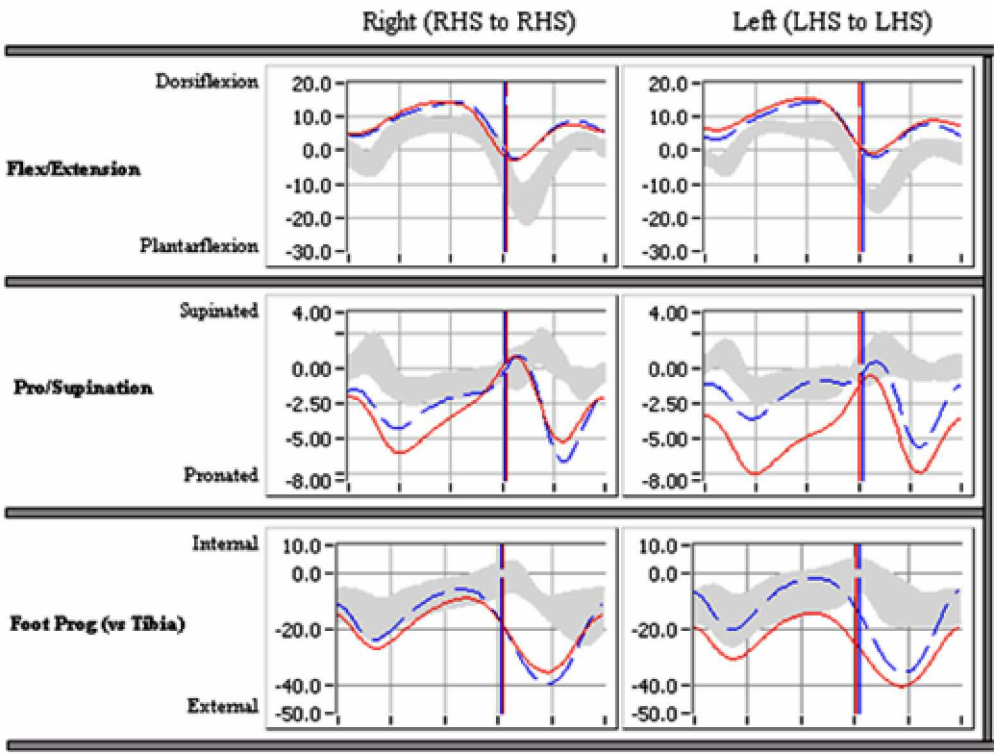

Figure 3.21 Ankle Joint Angles (Degrees), 4-year-old subjects.

3.3 Kinetics

The kinetic data of females and males of nine ages were examined separately. Kinetic data included the forces and moments formed at hip, knee, and ankle joints of both lower extremities in three planes or as movements of abduction/adduction, flexion/extension and rotation. Powers were also calculated for joint movements in sagittal plane. Mean, standard deviations, and ranges were calculated for each parameter at foot strike and toe off, for maximum and minimum values in stance and swing phases and for the times of the maximum and minimum values. The tables of four-year-old age group are presented in this section, and of other age groups in Appendix C.

Figures in each age group's section included the kinetic data plotted as graphs. Curves of females and males in each age group were plotted separately (males as dashed lines for separation) in the same graph with a gray band representing the gait analysis system's current normal band. This band has one standard deviation. Additionally, kinetic

data of four-year-old ages were shown in a more detailed way: Curves of four-year-old females and males were shown in separate graphs, and in the same graph, again with a normal band with one standard deviation. The figures of four-year-old age group are presented in this section, and of other age groups in Appendix C.

For better understanding of the tables, it is useful to state that:

St. = Stance, Sw. = Swing, Max. = Maximum, Min. = Minimum, SD = One Standard Deviation, R = Right, L = Left, Rot = Rotation, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Lat = Lateral, Vrt = Vertical, Fwd = Forward, Frc = Force, GRF = Ground Reaction Force, Mom = Moment, Pwr = Power.

For better understanding of the figures, it is useful to state that:

- x-axis represents 0-100 % of the gait cycle.
- The gray bands represent norm data of Orthotrak software (Motion Analysis Corp.) with one standard deviation.
- RHS = Right Heel Strike and LHS = Left Heel Strike.

Kinetic data of four-year-old subjects were presented in the tables and as graphs. For only this age, curves of four-year-old females and males were shown in separate graphs, and in the same graph, again with a normal band, representing system's current normative data, with one standard deviation.

Table 3.6 Stance Phase Kinetics of 4-year-old Female Subjects.

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	0.13	0.07	1.06	0.08	19.11	10.59	0.08	0.09	41.11	31.01
L_Hip_Rot_Frc	0.14	0.09	1.05	0.14	14.89	2.32	0.09	0.08	13.22	26.24
R_Hip_Abd_Frc	-0.07	0.04	0.24	0.08	47.22	1.39	-0.24	0.09	11.56	2.40
L_Hip_Abd_Frc	-0.08	0.04	0.25	0.08	47.11	2.42	-0.21	0.10	9.78	3.15
R_Hip_Flex_Frc	0.01	0.01	0.16	0.03	19.67	2.40	0.00	0.01	33.22	31.60
L_Hip_Flex_Frc	0.01	0.01	0.15	0.03	25.56	12.40	0.00	0.01	38.33	28.49
R_Knee_Rot_Frc	0.20	0.07	1.11	0.08	14.78	1.48	0.12	0.08	54.33	20.66
L_Knee_Rot_Frc	0.21	0.10	1.10	0.13	14.22	2.54	0.14	0.08	33.00	31.31
R_Knee_Abd_Frc	-0.05	0.02	0.36	0.05	43.33	13.61	-0.05	0.02	0.78	1.20
L_Knee_Abd_Frc	-0.04	0.03	0.36	0.03	46.22	11.82	-0.04	0.03	1.22	1.20
R_Knee_Flex_Frc	0.00	0.01	0.21	0.08	20.67	8.89	-0.01	0.01	20.44	28.74
L_Knee_Flex_Frc	-0.01	0.01	0.21	0.13	21.22	11.26	-0.02	0.02	6.89	17.00
R_Ank_Rot_Frc	0.22	0.07	1.18	0.09	19.00	10.98	0.15	0.08	54.44	20.76
L_Ank_Rot_Frc	0.24	0.10	1.17	0.16	18.00	11.52	0.17	0.08	33.00	31.31
R_Ank_Abd_Frc	-0.05	0.03	0.23	0.05	54.67	1.58	-0.07	0.05	9.22	13.53
L_Ank_Abd_Frc	-0.06	0.03	0.21	0.05	55.33	2.35	-0.09	0.03	7.33	11.95
R_Ank_Flex_Frc	0.00	0.01	0.05	0.02	20.67	5.74	-0.02	0.01	56.78	2.22
L_Ank_Flex_Frc	-0.01	0.02	0.04	0.02	25.00	5.59	-0.04	0.03	35.44	26.39
R_GRF_Fwd_Frc	-0.01	0.03	0.20	0.03	54.00	1.00	-0.20	0.03	9.78	1.39
L_GRF_Fwd_Frc	-0.02	0.06	0.19	0.04	53.33	1.58	-0.20	0.04	9.67	1.12
R_GRF_Lat_Frc	0.00	0.00	0.09	0.02	21.44	9.94	-0.02	0.01	28.22	31.15
L_GRF_Lat_Frc	0.01	0.02	0.08	0.02	15.56	4.77	-0.02	0.02	22.11	28.95
R_GRF_Vrt_Frc	0.05	0.14	1.22	0.10	22.33	13.79	0.02	0.05	6.67	20.00
L_GRF_Vrt_Frc	0.06	0.12	1.21	0.17	18.33	11.73	0.02	0.04	13.22	26.24
R_Hip_Rot_Mom	-0.01	0.01	0.11	0.04	29.11	18.88	-0.07	0.03	32.44	15.75
L_Hip_Rot_Mom	-0.02	0.03	0.12	0.07	23.33	17.78	-0.10	0.05	40.67	12.81
R_Hip_Abd_Mom	0.02	0.06	0.51	0.06	18.44	1.59	-0.03	0.04	40.11	30.12
L_Hip_Abd_Mom	0.01	0.04	0.46	0.06	21.89	9.58	-0.01	0.04	32.89	30.83
R_Hip_Flex_Mom	0.32	0.10	0.46	0.17	6.44	3.54	-0.48	0.16	51.00	1.94
L_Hip_Flex_Mom	0.30	0.11	0.40	0.14	5.33	1.50	-0.48	0.11	50.67	2.00
R_Knee_Rot_Mom	0.00	0.02	0.06	0.03	32.78	21.57	-0.08	0.04	26.33	18.43
L_Knee_Rot_Mom	0.00	0.03	0.07	0.05	25.67	21.12	-0.11	0.05	39.44	17.71
R_Knee_Abd_Mom	-0.02	0.02	0.20	0.05	16.78	0.83	-0.02	0.02	18.11	27.89
L_Knee_Abd_Mom	-0.03	0.03	0.24	0.12	20.56	10.82	-0.04	0.03	4.78	13.25
R_Knee_Flex_Mom	-0.11	0.04	0.22	0.10	30.11	21.68	-0.18	0.06	36.33	13.79
L_Knee_Flex_Mom	-0.09	0.04	0.16	0.04	38.11	22.54	-0.19	0.07	33.78	13.20
R_Ank_Rot_Mom	0.00	0.02	0.08	0.04	28.44	16.36	-0.06	0.03	35.22	22.16
L_Ank_Rot_Mom	0.00	0.03	0.09	0.05	37.78	17.11	-0.09	0.08	25.78	20.48
R_Ank_Abd_Mom	0.00	0.01	0.09	0.05	53.11	2.85	-0.03	0.02	16.00	8.93
L_Ank_Abd_Mom	0.02	0.02	0.13	0.06	43.67	16.14	0.00	0.02	27.11	25.52
R_Ank_Flex_Mom	0.03	0.02	0.91	0.12	41.44	10.30	0.02	0.03	1.78	2.11
L_Ank_Flex_Mom	0.04	0.04	0.93	0.11	43.56	9.79	0.02	0.06	8.44	19.11
R_Hip_Pwr	0.21	0.15	0.78	0.23	28.67	24.20	-0.70	0.20	45.33	2.78
L_Hip_Pwr	0.39	0.20	0.79	0.33	25.56	25.43	-0.63	0.16	45.11	3.02
R_Knee_Pwr	0.02	0.10	0.33	0.23	17.78	13.53	-1.09	0.32	58.89	1.05
L_Knee_Pwr	-0.11	0.12	0.18	0.14	26.22	20.81	-0.99	0.24	59.22	1.79
R_Ank_Pwr	-0.01	0.03	1.87	0.49	52.00	1.00	-0.79	0.64	20.56	10.20
L_Ank_Pwr	-0.01	0.03	1.85	0.36	52.56	3.00	-0.67	0.40	24.89	11.27

Table 3.7 Swing Phase Kinetics of 4-year-old Female Subjects.

	Maximum Swing		Time of Max. Sw.		Minimum Swing		Time of Min. Sw.		Toe Off	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	0.05	0.05	62.74	6.45	-0.11	0.01	74.51	13.73	0.05	0.06
L_Hip_Rot_Frc	0.10	0.07	60.72	1.28	-0.11	0.01	70.27	7.48	0.10	0.07
R_Hip_Abd_Frc	0.02	0.00	73.62	10.11	0.00	0.01	78.18	16.46	0.01	0.01
L_Hip_Abd_Frc	0.02	0.01	67.83	8.86	0.00	0.01	85.83	15.21	0.02	0.01
R_Hip_Flex_Frc	0.01	0.00	68.18	8.21	-0.01	0.00	87.18	14.99	0.00	0.01
L_Hip_Flex_Frc	0.01	0.01	68.27	11.15	0.00	0.00	84.38	15.45	0.01	0.01
R_Knee_Rot_Frc	0.09	0.05	62.51	5.79	-0.04	0.00	72.96	10.51	0.09	0.05
L_Knee_Rot_Frc	0.13	0.06	60.72	1.28	-0.04	0.00	80.16	13.70	0.13	0.06
R_Knee_Abd_Frc	0.07	0.04	62.40	5.46	-0.03	0.01	88.29	11.41	0.07	0.04
L_Knee_Abd_Frc	0.10	0.03	60.72	1.28	-0.03	0.01	92.94	4.97	0.10	0.03
R_Knee_Flex_Frc	0.01	0.02	66.85	13.37	-0.01	0.01	75.29	11.18	0.01	0.02
L_Knee_Flex_Frc	0.04	0.03	64.61	11.69	-0.01	0.01	68.05	3.25	0.04	0.03
R_Ank_Rot_Frc	0.11	0.05	62.74	6.45	-0.03	0.01	71.85	8.64	0.11	0.06
L_Ank_Rot_Frc	0.16	0.07	60.72	1.28	-0.03	0.01	71.16	5.99	0.16	0.07
R_Ank_Abd_Frc	0.09	0.04	62.40	5.46	-0.02	0.00	77.29	13.33	0.09	0.04
L_Ank_Abd_Frc	0.10	0.03	60.72	1.28	-0.01	0.00	80.16	13.36	0.10	0.03
R_Ank_Flex_Frc	0.00	0.00	78.40	8.81	-0.01	0.01	62.51	5.45	-0.01	0.01
L_Ank_Flex_Frc	0.00	0.00	82.16	13.75	-0.01	0.01	63.16	7.02	-0.01	0.01
R_GRF_Fwd_Frc	0.04	0.03	62.40	5.46	0.00	0.00	65.18	4.44	0.04	0.03
L_GRF_Fwd_Frc	0.06	0.05	60.72	1.28	0.00	0.00	64.61	2.56	0.06	0.05
R_GRF_Lat_Frc	0.00	0.00	64.51	4.91	0.00	0.01	63.29	5.22	0.00	0.01
L_GRF_Lat_Frc	0.00	0.00	64.16	2.75	-0.01	0.01	61.50	1.18	-0.01	0.01
R_GRF_Vrt_Frc	0.10	0.06	62.40	5.46	0.00	0.00	65.18	4.44	0.10	0.06
L_GRF_Vrt_Frc	0.18	0.15	60.83	1.31	0.00	0.00	64.94	2.41	0.17	0.15
R_Hip_Rot_Mom	0.02	0.01	69.18	10.44	-0.01	0.00	74.40	13.56	0.01	0.02
L_Hip_Rot_Mom	0.01	0.01	71.94	10.64	-0.02	0.02	72.16	17.04	-0.01	0.02
R_Hip_Abd_Mom	0.02	0.02	76.40	11.14	-0.02	0.02	76.62	16.81	0.00	0.03
L_Hip_Abd_Mom	0.02	0.02	74.38	15.85	-0.01	0.01	74.27	16.90	0.01	0.03
R_Hip_Flex_Mom	0.08	0.04	97.07	1.34	-0.16	0.07	62.40	5.46	-0.16	0.07
L_Hip_Flex_Mom	0.06	0.03	98.38	0.45	-0.18	0.03	60.72	1.28	-0.18	0.03
R_Knee_Rot_Mom	0.01	0.01	64.07	5.55	0.00	0.00	68.18	8.57	0.01	0.01
L_Knee_Rot_Mom	0.00	0.00	66.38	3.46	-0.02	0.02	63.72	7.66	-0.02	0.02
R_Knee_Abd_Mom	0.03	0.03	68.74	9.71	-0.02	0.01	73.07	12.85	0.02	0.03
L_Knee_Abd_Mom	0.05	0.03	64.61	11.69	-0.02	0.01	74.05	10.20	0.05	0.03
R_Knee_Flex_Mom	0.11	0.05	62.62	6.12	-0.06	0.02	91.85	8.82	0.11	0.05
L_Knee_Flex_Mom	0.11	0.02	60.72	1.28	-0.04	0.01	94.50	5.68	0.11	0.02
R_Ank_Rot_Mom	0.00	0.00	68.07	8.55	-0.01	0.01	63.96	5.48	-0.01	0.01
L_Ank_Rot_Mom	0.02	0.02	61.50	2.43	0.00	0.00	67.72	3.19	0.02	0.02
R_Ank_Abd_Mom	0.02	0.01	63.96	10.09	0.00	0.00	67.40	4.07	0.02	0.01
L_Ank_Abd_Mom	0.02	0.01	65.05	12.64	0.00	0.00	67.50	3.73	0.02	0.01
R_Ank_Flex_Mom	0.08	0.04	62.85	6.78	-0.02	0.01	68.51	3.15	0.08	0.04
L_Ank_Flex_Mom	0.14	0.07	60.72	1.28	-0.02	0.01	68.83	1.73	0.14	0.07
R_Hip_Pwr	0.45	0.24	64.51	11.38	-0.05	0.03	84.62	6.24	0.45	0.24
L_Hip_Pwr	0.51	0.15	60.83	1.21	-0.03	0.02	82.83	7.39	0.51	0.15
R_Knee_Pwr	0.10	0.05	70.07	2.70	-0.86	0.34	63.96	10.09	-0.82	0.41
L_Knee_Pwr	0.11	0.06	69.94	2.13	-0.87	0.21	60.72	1.28	-0.87	0.21
R_Ank_Pwr	0.19	0.10	62.40	5.46	0.00	0.00	92.29	5.38	0.19	0.10
L_Ank_Pwr	0.38	0.23	61.50	2.26	0.00	0.00	90.50	3.09	0.37	0.24

Table 3.8 Stance Phase Kinetics of 4-year-old Male Subjects.

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	0.15	0.13	0.91	0.36	13.90	5.69	0.12	0.10	24.00	30.99
L_Hip_Rot_Frc	0.18	0.15	1.00	0.41	13.60	5.27	0.14	0.15	24.60	31.81
R_Hip_Abd_Frc	-0.06	0.05	0.24	0.11	42.60	15.15	-0.14	0.09	8.10	5.02
L_Hip_Abd_Frc	-0.07	0.06	0.23	0.11	43.20	15.49	-0.17	0.09	7.10	3.84
R_Hip_Flex_Frc	0.01	0.02	0.15	0.06	27.90	18.23	0.00	0.01	18.30	28.80
L_Hip_Flex_Frc	0.01	0.02	0.15	0.06	25.90	17.28	-0.01	0.02	23.00	29.88
R_Knee_Rot_Frc	0.20	0.15	0.94	0.38	17.00	12.21	0.14	0.10	36.00	31.00
L_Knee_Rot_Frc	0.22	0.16	1.03	0.42	13.00	5.29	0.15	0.13	36.90	31.81
R_Knee_Abd_Frc	-0.04	0.04	0.31	0.12	47.00	16.81	-0.05	0.05	1.70	1.89
L_Knee_Abd_Frc	-0.06	0.03	0.31	0.12	43.70	19.53	-0.07	0.04	2.10	1.37
R_Knee_Flex_Frc	0.00	0.02	0.15	0.08	15.80	6.01	-0.01	0.02	18.10	26.69
L_Knee_Flex_Frc	-0.01	0.02	0.18	0.09	15.70	5.68	-0.01	0.02	12.20	23.81
R_Ank_Rot_Frc	0.21	0.15	0.98	0.39	19.80	15.33	0.16	0.11	29.90	31.53
L_Ank_Rot_Frc	0.23	0.16	1.06	0.44	16.40	11.87	0.17	0.14	36.90	31.81
R_Ank_Abd_Frc	-0.05	0.05	0.22	0.12	51.00	18.09	-0.09	0.07	14.70	17.11
L_Ank_Abd_Frc	-0.07	0.05	0.20	0.09	51.60	18.44	-0.11	0.07	9.20	12.40
R_Ank_Flex_Frc	0.00	0.01	0.08	0.04	23.70	13.72	-0.02	0.01	36.90	28.32
L_Ank_Flex_Frc	0.00	0.01	0.10	0.05	22.30	14.53	-0.01	0.01	24.00	30.39
R_GRF_Fwd_Frc	-0.01	0.02	0.18	0.07	49.80	17.76	-0.20	0.08	8.60	5.04
L_GRF_Fwd_Frc	0.00	0.01	0.21	0.09	49.90	17.89	-0.20	0.09	10.20	3.99
R_GRF_Lat_Frc	0.00	0.01	0.06	0.03	15.20	6.58	-0.04	0.05	4.60	3.72
L_GRF_Lat_Frc	0.00	0.01	0.07	0.04	26.20	18.49	-0.04	0.04	7.90	16.68
R_GRF_Vrt_Frc	0.05	0.14	1.01	0.41	16.00	13.42	0.03	0.08	0.10	0.32
L_GRF_Vrt_Frc	0.03	0.05	1.08	0.45	19.80	15.49	0.03	0.05	6.10	19.29
R_Hip_Rot_Mom	-0.02	0.03	0.12	0.11	39.00	23.84	-0.18	0.16	26.90	20.79
L_Hip_Rot_Mom	-0.02	0.04	0.09	0.09	35.70	25.10	-0.12	0.10	32.70	20.61
R_Hip_Abd_Mom	0.00	0.11	0.45	0.23	22.30	17.24	-0.05	0.16	12.40	24.63
L_Hip_Abd_Mom	0.01	0.07	0.50	0.22	23.80	16.58	-0.03	0.04	18.40	29.69
R_Hip_Flex_Mom	0.27	0.19	0.35	0.24	4.00	2.00	-0.48	0.30	47.50	17.00
L_Hip_Flex_Mom	0.32	0.19	0.44	0.24	4.90	2.85	-0.42	0.28	48.20	17.55
R_Knee_Rot_Mom	-0.02	0.03	0.09	0.11	33.00	25.52	-0.17	0.11	22.20	19.64
L_Knee_Rot_Mom	-0.01	0.04	0.05	0.09	28.40	25.36	-0.13	0.10	28.40	20.04
R_Knee_Abd_Mom	-0.01	0.05	0.19	0.09	30.30	22.56	-0.08	0.19	16.50	24.59
L_Knee_Abd_Mom	-0.02	0.04	0.25	0.13	20.30	12.42	-0.03	0.05	0.90	2.23
R_Knee_Flex_Mom	-0.13	0.10	0.23	0.17	44.60	23.88	-0.21	0.13	31.40	18.11
L_Knee_Flex_Mom	-0.14	0.07	0.19	0.14	45.20	24.53	-0.23	0.14	29.40	18.51
R_Ank_Rot_Mom	0.02	0.02	0.17	0.12	22.40	19.43	-0.09	0.10	32.20	24.84
L_Ank_Rot_Mom	0.01	0.04	0.13	0.10	27.90	20.45	-0.05	0.08	34.10	24.64
R_Ank_Abd_Mom	0.00	0.03	0.07	0.04	45.20	19.58	-0.12	0.17	27.50	16.58
L_Ank_Abd_Mom	0.00	0.02	0.07	0.07	42.00	24.56	-0.07	0.06	25.30	17.90
R_Ank_Flex_Mom	0.05	0.05	0.75	0.33	39.60	17.05	0.04	0.07	7.60	18.34
L_Ank_Flex_Mom	0.03	0.05	0.82	0.35	39.80	17.87	0.01	0.07	3.20	2.90
R_Hip_Pwr	0.37	0.31	1.04	0.87	30.90	27.63	-0.66	0.41	42.00	15.41
L_Hip_Pwr	0.41	0.31	0.86	0.46	29.20	28.02	-0.54	0.39	39.20	16.31
R_Knee_Pwr	-0.11	0.32	0.40	0.35	27.90	18.63	-1.59	1.44	54.20	19.15
L_Knee_Pwr	-0.17	0.13	0.45	0.40	34.10	19.96	-1.21	0.98	54.70	19.34
R_Ank_Pwr	0.00	0.07	1.70	0.72	47.50	16.88	-0.50	0.49	20.20	12.90
L_Ank_Pwr	-0.01	0.05	1.51	0.62	48.80	17.33	-0.48	0.49	25.40	15.23

Table 3.9 Swing Phase Kinetics of 4-year-old Male Subjects.

	Maximum Swing		Time of Max. Sw.		Minimum Swing		Time of Min. Sw.		Toe Off	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	0.17	0.13	61.21	2.29	-0.07	0.04	74.91	13.03	0.17	0.13
L_Hip_Rot_Frc	0.16	0.17	61.92	2.78	-0.07	0.05	72.22	10.57	0.16	0.17
R_Hip_Abd_Frc	0.03	0.02	63.01	5.56	-0.01	0.01	83.21	15.04	0.02	0.03
L_Hip_Abd_Frc	0.02	0.02	66.72	5.12	-0.01	0.01	80.02	14.73	0.02	0.02
R_Hip_Flex_Frc	0.01	0.01	65.71	6.22	0.00	0.00	73.61	14.87	0.01	0.01
L_Hip_Flex_Frc	0.01	0.02	68.82	13.74	0.00	0.00	72.72	10.95	0.01	0.02
R_Knee_Rot_Frc	0.17	0.11	61.21	2.29	-0.03	0.02	75.21	12.48	0.17	0.11
L_Knee_Rot_Frc	0.17	0.14	61.92	2.78	-0.03	0.02	72.22	9.96	0.17	0.14
R_Knee_Abd_Frc	0.13	0.09	61.21	2.29	-0.03	0.02	83.41	12.62	0.13	0.09
L_Knee_Abd_Frc	0.11	0.08	61.92	2.78	-0.03	0.02	82.22	13.83	0.11	0.08
R_Knee_Flex_Frc	0.03	0.03	68.91	14.99	-0.01	0.01	71.61	9.90	0.02	0.03
L_Knee_Flex_Frc	0.03	0.03	68.12	13.25	-0.01	0.01	68.52	6.03	0.02	0.03
R_Ank_Rot_Frc	0.19	0.12	61.21	2.29	-0.02	0.01	72.71	8.72	0.19	0.12
L_Ank_Rot_Frc	0.19	0.14	61.92	2.78	-0.02	0.01	70.42	5.00	0.19	0.14
R_Ank_Abd_Frc	0.14	0.09	61.21	2.29	-0.01	0.01	76.61	12.79	0.14	0.09
L_Ank_Abd_Frc	0.11	0.09	61.92	2.78	-0.02	0.01	75.22	12.37	0.11	0.09
R_Ank_Flex_Frc	0.00	0.00	76.81	11.79	-0.01	0.01	62.01	3.39	-0.01	0.01
L_Ank_Flex_Frc	0.01	0.02	76.02	13.56	0.00	0.00	64.72	4.77	0.01	0.03
R_GRF_Fwd_Frc	0.05	0.05	61.21	2.29	0.00	0.01	66.61	5.17	0.05	0.05
L_GRF_Fwd_Frc	0.05	0.06	62.22	3.43	0.00	0.00	65.22	4.27	0.05	0.06
R_GRF_Lat_Frc	0.00	0.00	65.11	5.86	0.00	0.01	64.81	4.31	0.00	0.01
L_GRF_Lat_Frc	0.00	0.01	67.92	11.34	-0.01	0.01	63.22	3.26	0.00	0.01
R_GRF_Vrt_Frc	0.18	0.17	61.21	2.29	0.00	0.00	67.71	5.56	0.18	0.17
L_GRF_Vrt_Frc	0.18	0.19	65.02	11.68	0.00	0.01	66.52	5.45	0.18	0.19
R_Hip_Rot_Mom	0.03	0.03	67.31	9.22	-0.01	0.02	70.41	11.90	0.02	0.04
L_Hip_Rot_Mom	0.02	0.04	68.92	13.12	-0.02	0.02	73.22	13.46	0.01	0.05
R_Hip_Abd_Mom	0.06	0.07	66.91	9.08	-0.02	0.01	67.71	8.31	0.05	0.08
L_Hip_Abd_Mom	0.09	0.14	70.62	15.12	-0.02	0.02	70.32	11.30	0.07	0.16
R_Hip_Flex_Mom	0.07	0.05	93.41	10.94	-0.26	0.20	61.21	2.29	-0.26	0.20
L_Hip_Flex_Mom	0.04	0.04	87.92	14.45	-0.19	0.19	61.92	2.78	-0.19	0.19
R_Knee_Rot_Mom	0.02	0.02	63.71	3.76	-0.01	0.02	68.51	9.76	0.01	0.03
L_Knee_Rot_Mom	0.01	0.01	70.62	11.21	-0.02	0.02	69.72	13.53	-0.01	0.02
R_Knee_Abd_Mom	0.06	0.06	67.01	12.50	-0.01	0.01	74.21	13.82	0.06	0.07
L_Knee_Abd_Mom	0.08	0.12	61.92	2.78	-0.02	0.01	75.42	12.24	0.08	0.12
R_Knee_Flex_Mom	0.18	0.15	61.21	2.29	-0.05	0.03	85.71	13.61	0.18	0.15
L_Knee_Flex_Mom	0.14	0.12	62.12	2.83	-0.03	0.02	79.72	11.83	0.14	0.13
R_Ank_Rot_Mom	0.01	0.02	67.71	9.58	-0.02	0.02	63.81	3.92	-0.01	0.03
L_Ank_Rot_Mom	0.02	0.02	69.92	13.48	-0.01	0.01	70.42	11.13	0.01	0.02
R_Ank_Abd_Mom	0.04	0.03	62.01	2.96	-0.01	0.01	68.91	6.43	0.03	0.04
L_Ank_Abd_Mom	0.04	0.06	63.72	6.03	-0.02	0.03	72.62	11.73	0.04	0.07
R_Ank_Flex_Mom	0.11	0.07	61.21	2.29	-0.02	0.01	69.71	5.51	0.11	0.07
L_Ank_Flex_Mom	0.12	0.09	63.22	6.19	-0.03	0.04	74.22	13.28	0.12	0.09
R_Hip_Pwr	0.86	0.90	61.41	2.22	-0.04	0.02	77.71	10.13	0.85	0.90
L_Hip_Pwr	0.58	0.54	62.42	3.15	-0.03	0.02	81.62	12.35	0.56	0.50
R_Knee_Pwr	0.08	0.07	70.41	3.37	-1.52	1.35	61.31	2.24	-1.51	1.36
L_Knee_Pwr	0.15	0.16	73.82	9.98	-1.14	1.06	62.22	2.98	-1.13	1.06
R_Ank_Pwr	0.27	0.27	62.71	4.37	-0.01	0.01	83.91	13.50	0.27	0.27
L_Ank_Pwr	0.28	0.20	62.42	3.94	-0.02	0.04	85.12	14.70	0.28	0.20

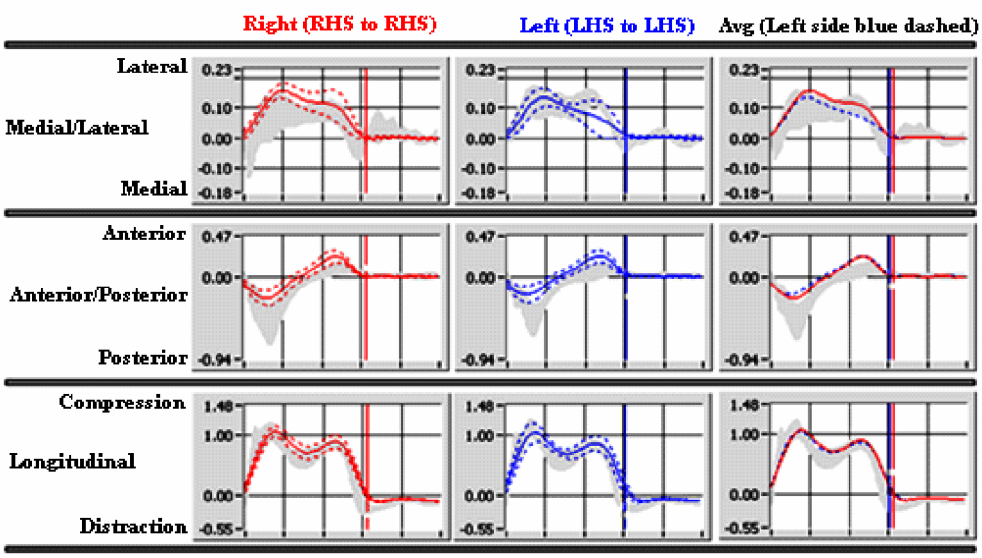

Figure 3.22 Hip Joint Forces (N), 4-year-old females.

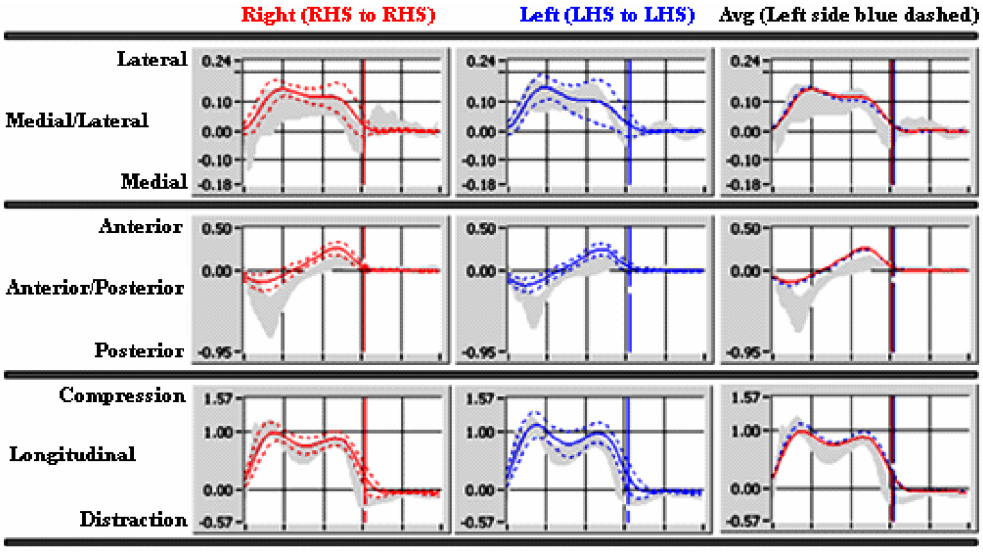

Figure 3.23. Hip Joint Forces (N), 4-year old males.

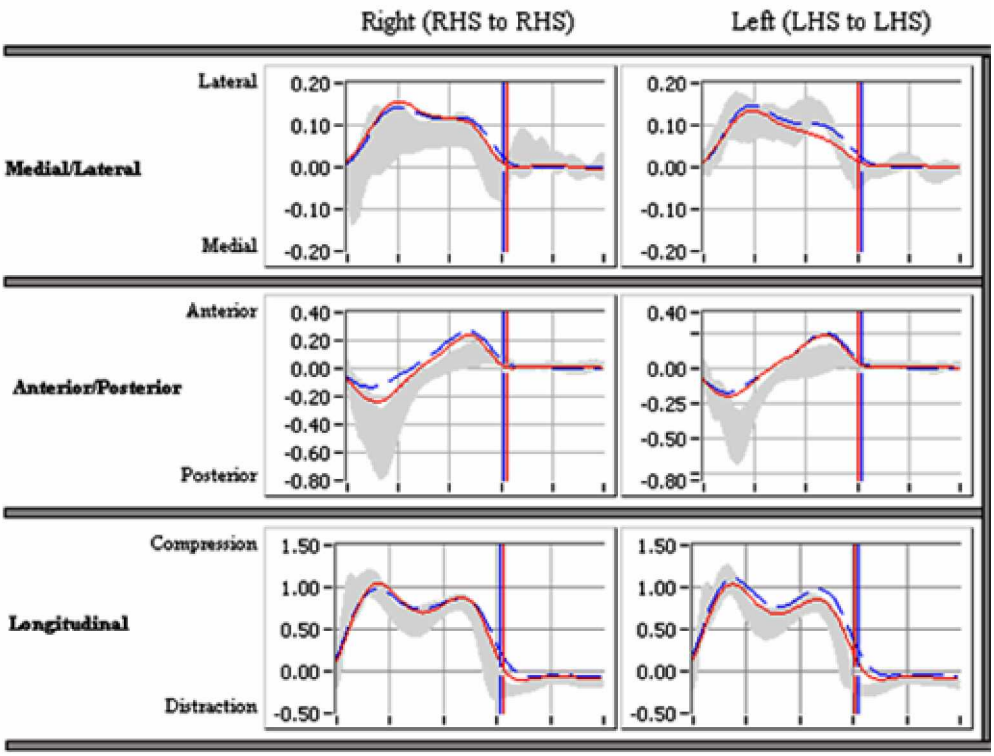

Figure 3.24 Hip Joint Forces (N), 4-year-old subjects.

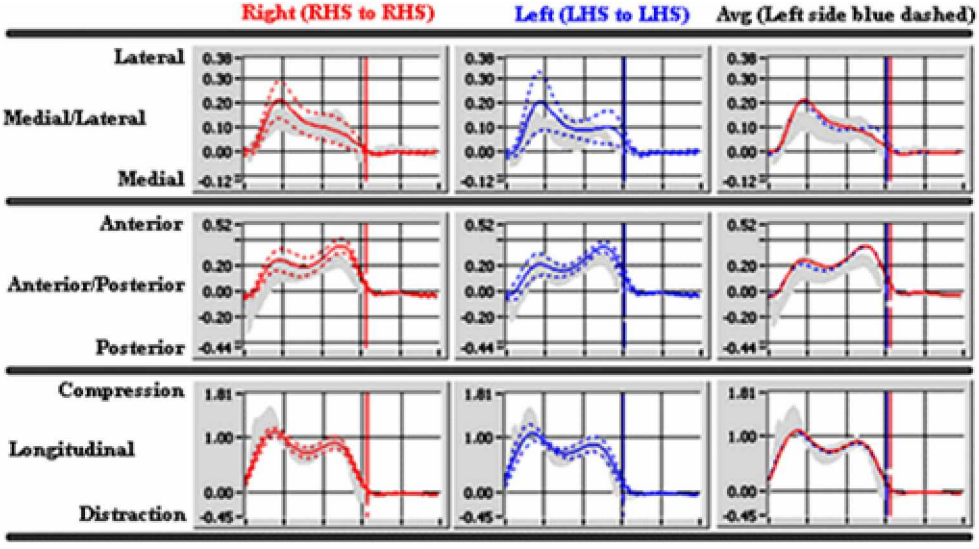

Figure 3.25 Knee Joint Forces (N), 4-year-old females.

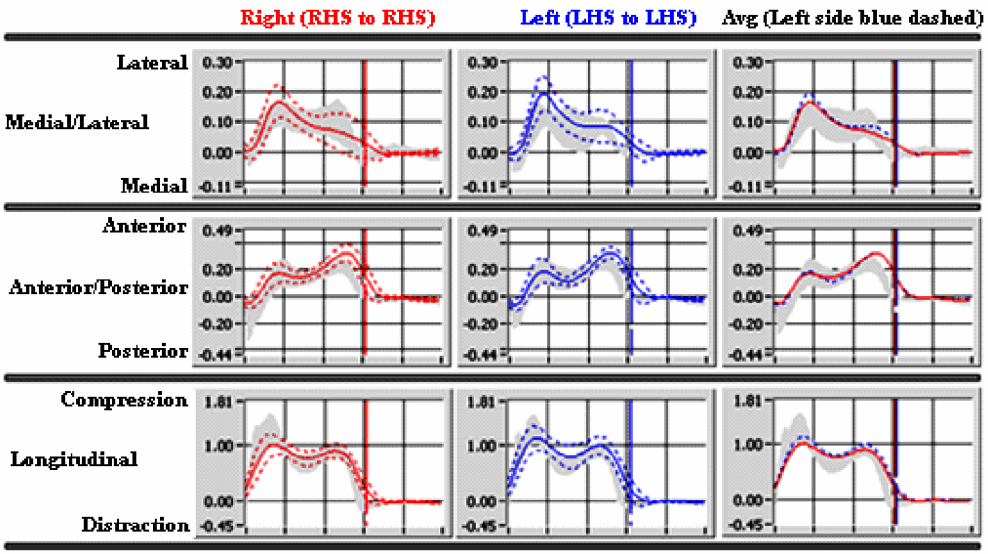

Figure 3.26 Knee Joint Forces (N), 4-year old males.

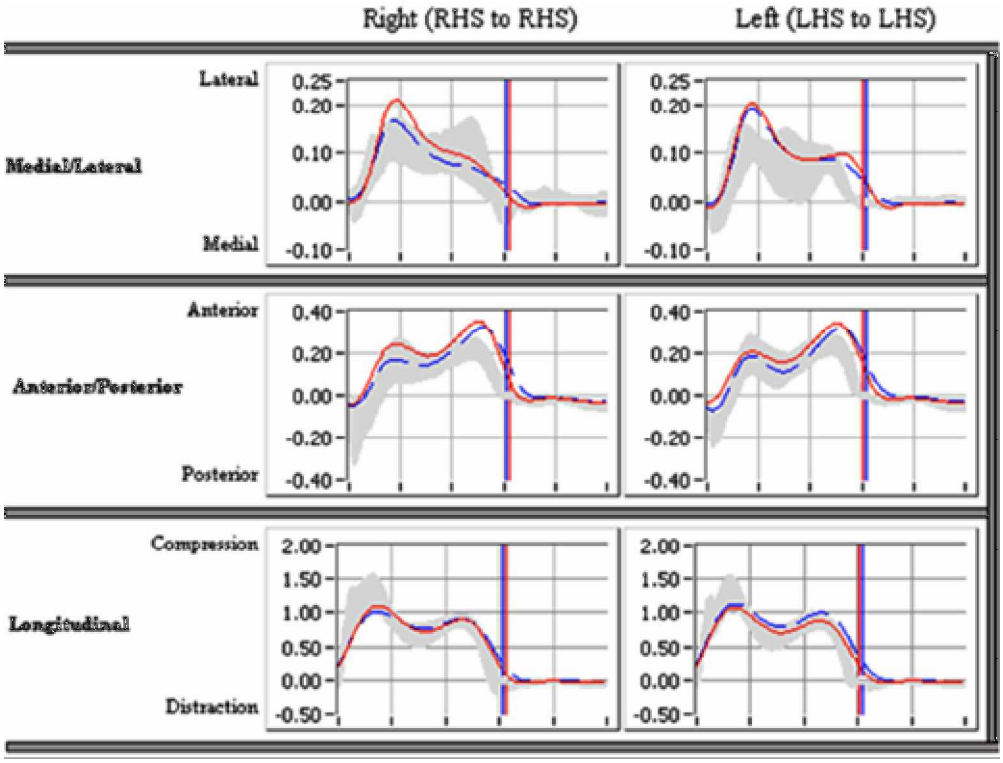

Figure 3.27 Knee Joint Forces (N), 4-year-old subjects.

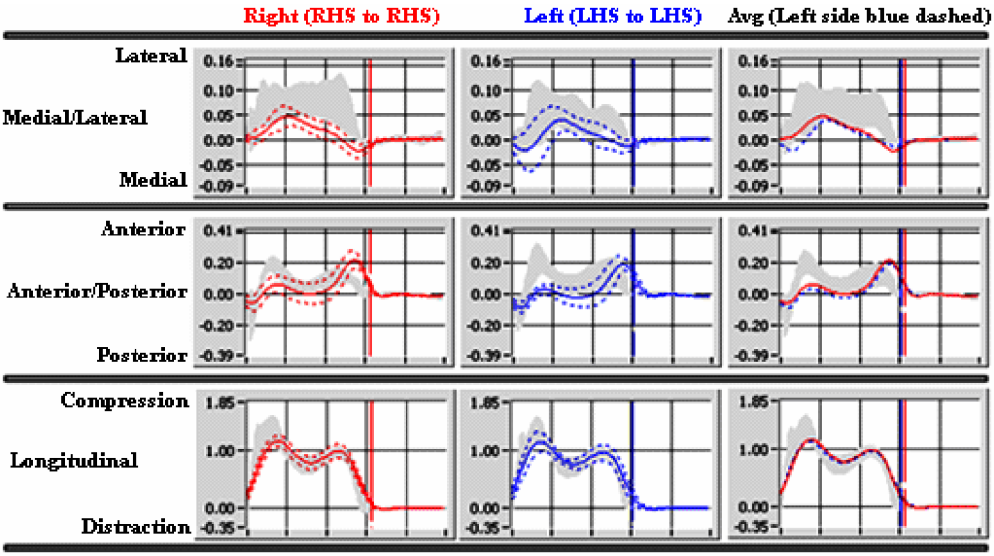

Figure 3.28 Ankle Joint Forces (N), 4-year-old females.

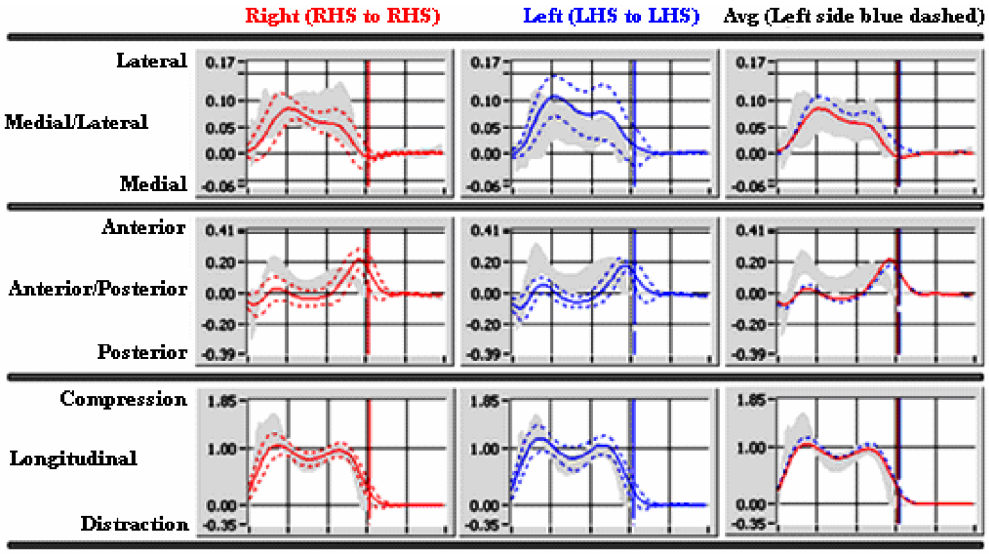

Figure 3.29 Ankle Joint Forces (N), 4-year old males.

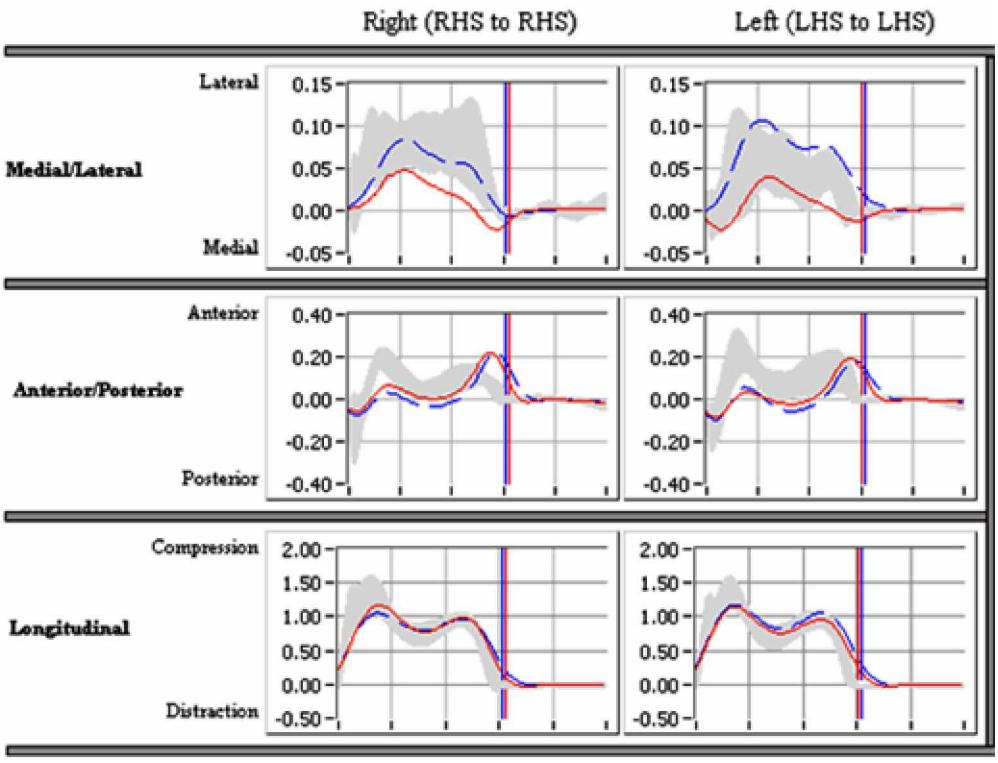

Figure 3.30 Ankle Joint Forces (N), 4-year-old subjects.

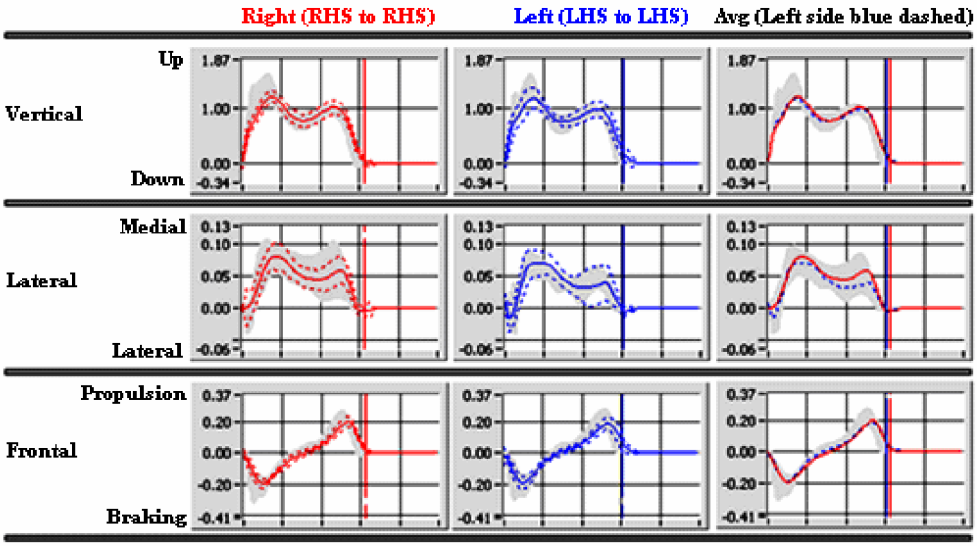

Figure 3.31 Ground Reaction Forces (N), 4-year-old females.

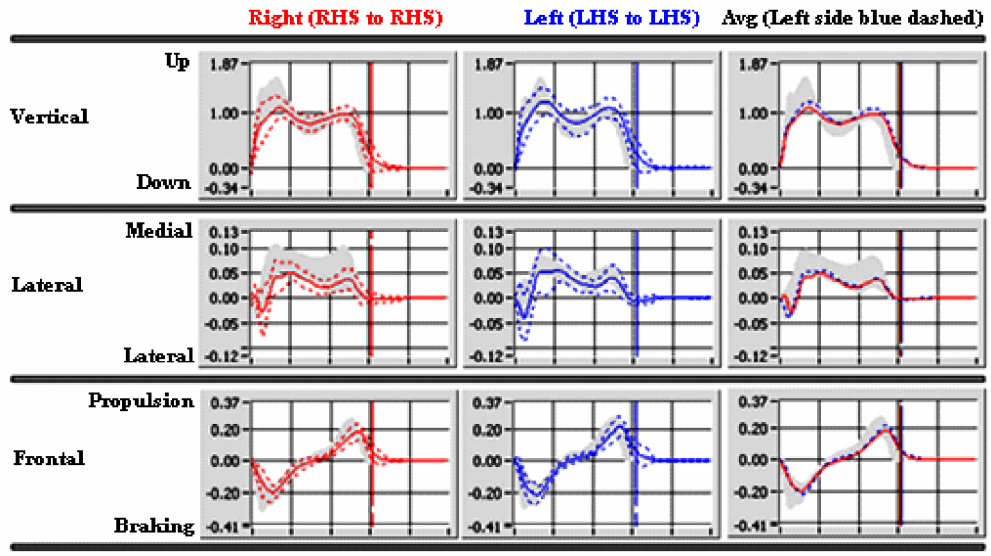

Figure 3.32 Ground Reaction Forces (N), 4-year old males.

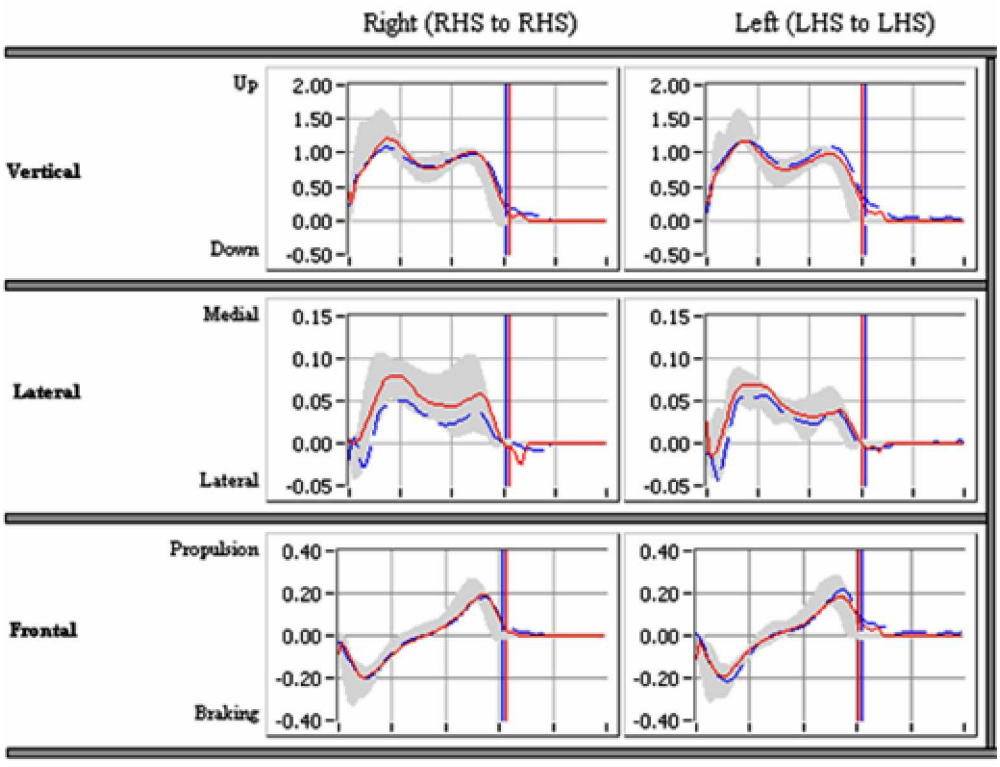

Figure 3.33 Ground Reaction Forces (N), 4-year-old subjects.

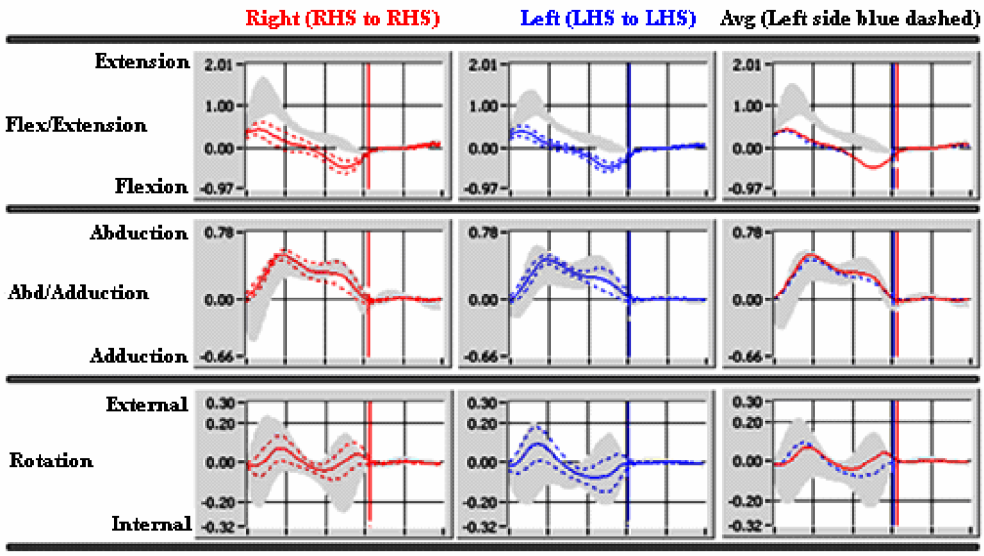

Figure 3.34 Hip Joint Moments (Nm/kg), 4-year-old females.

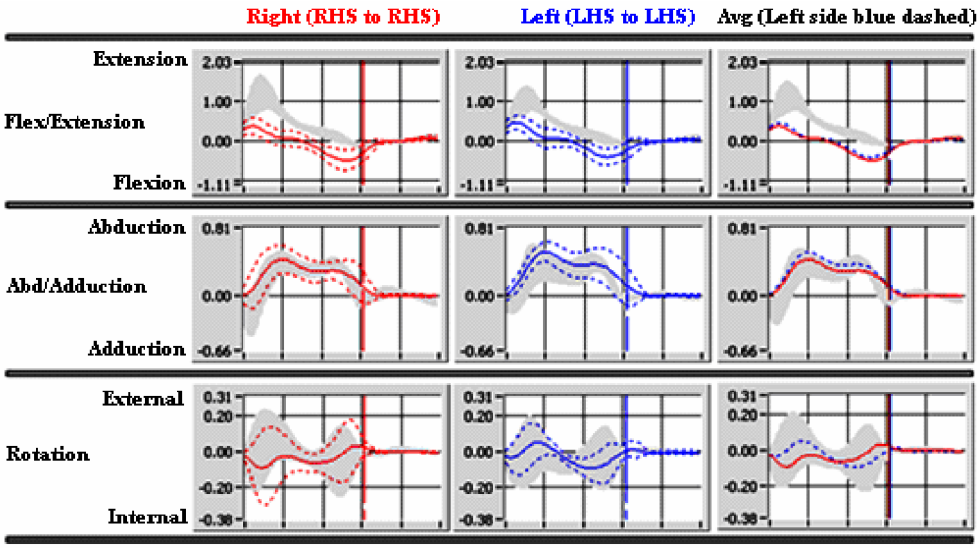

Figure 3.35 Hip Joint Moments (Nm/kg), 4-year-old males.

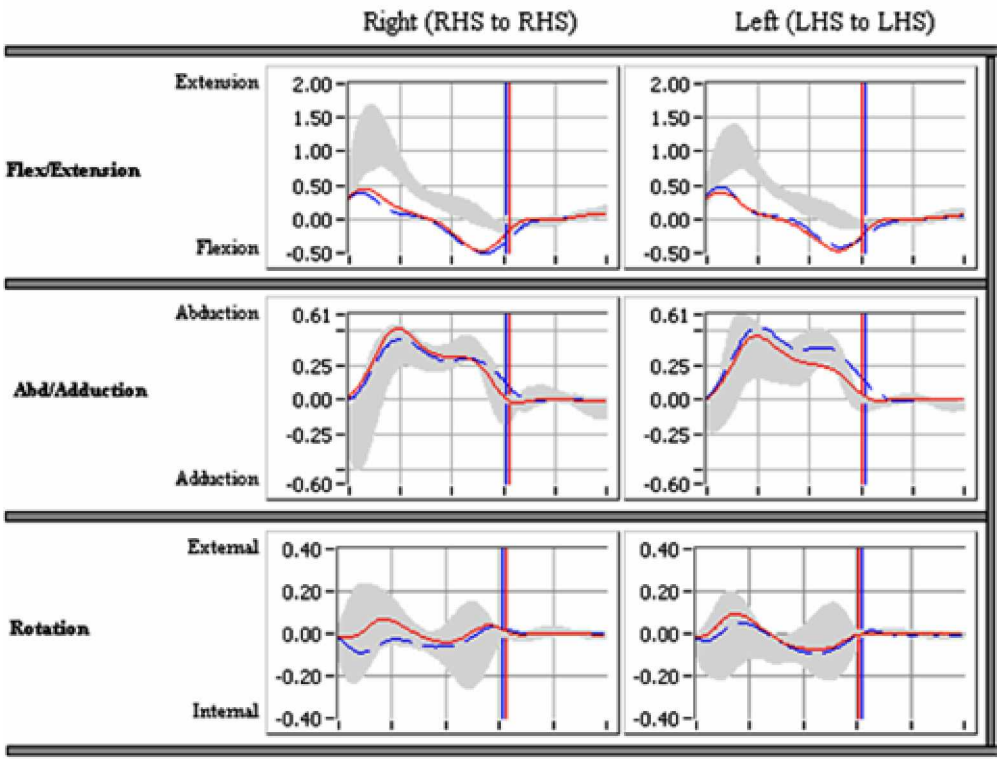

Figure 3.36 Hip Joint Moments (Nm/Kg), 4-year-old subjects.

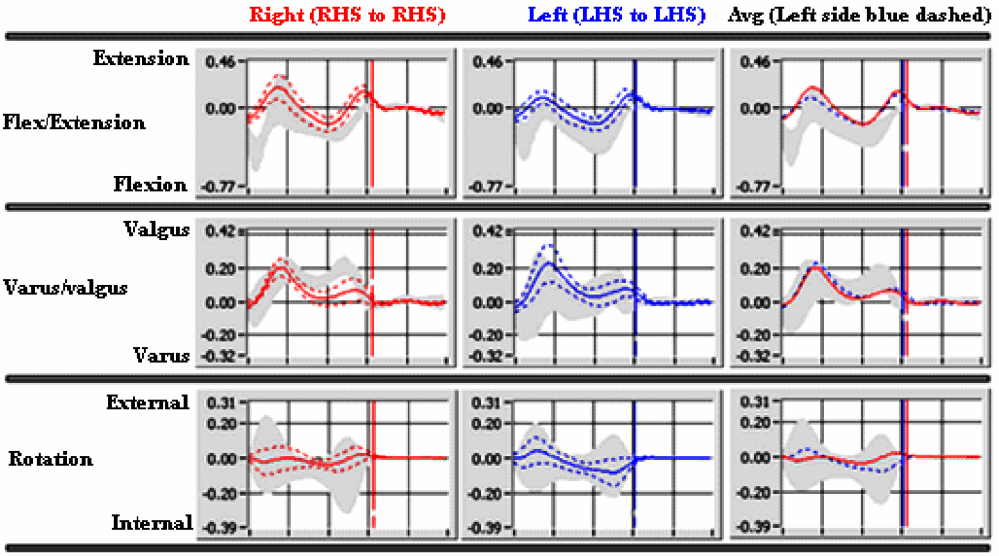

Figure 3.37 Knee Joint Moments (Nm/kg), 4-year-old females.

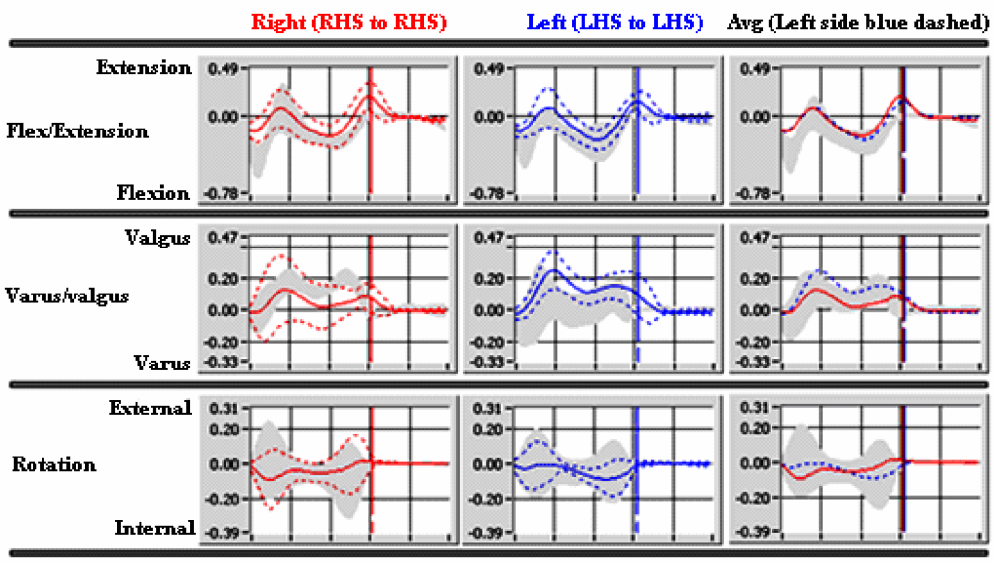

Figure 3.38 Knee Joint Moments (Nm/kg), 4-year-old males.

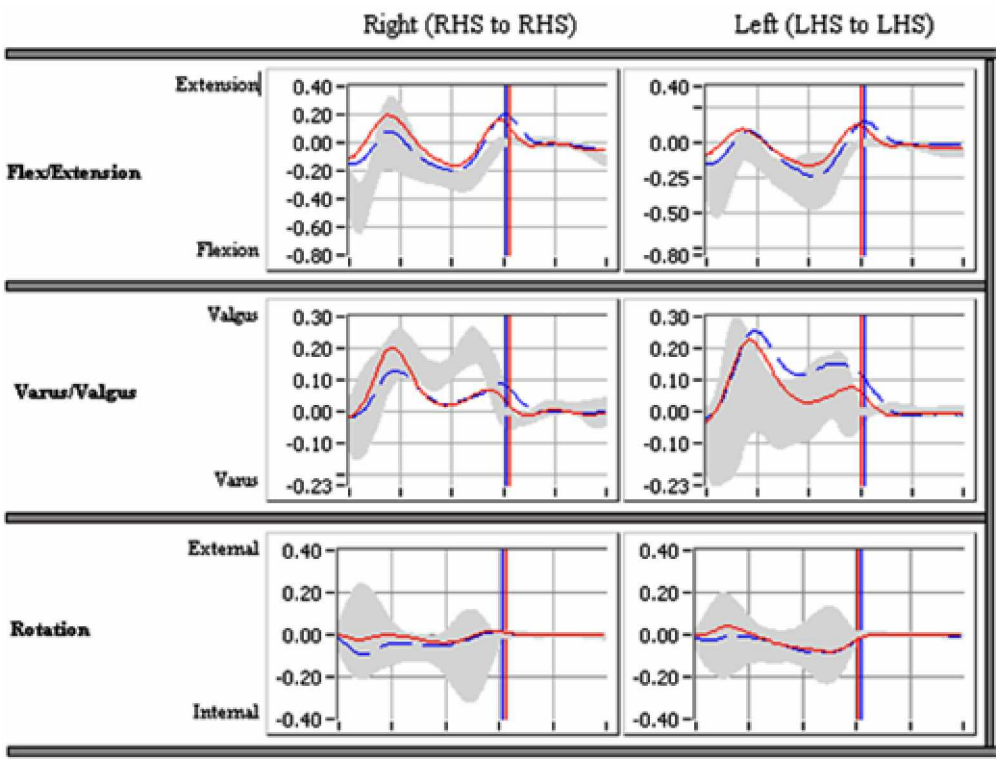

Figure 3.39 Knee Joint Moments (Nm/Kg), 4-year-old subjects.

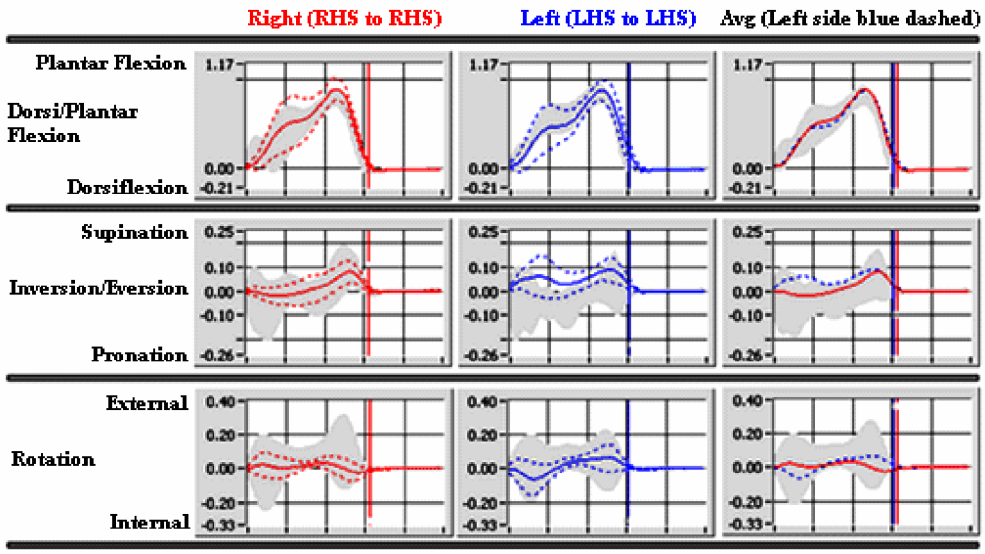

Figure 3.40 Ankle Joint Moments (Nm/kg), 4-year-old females.

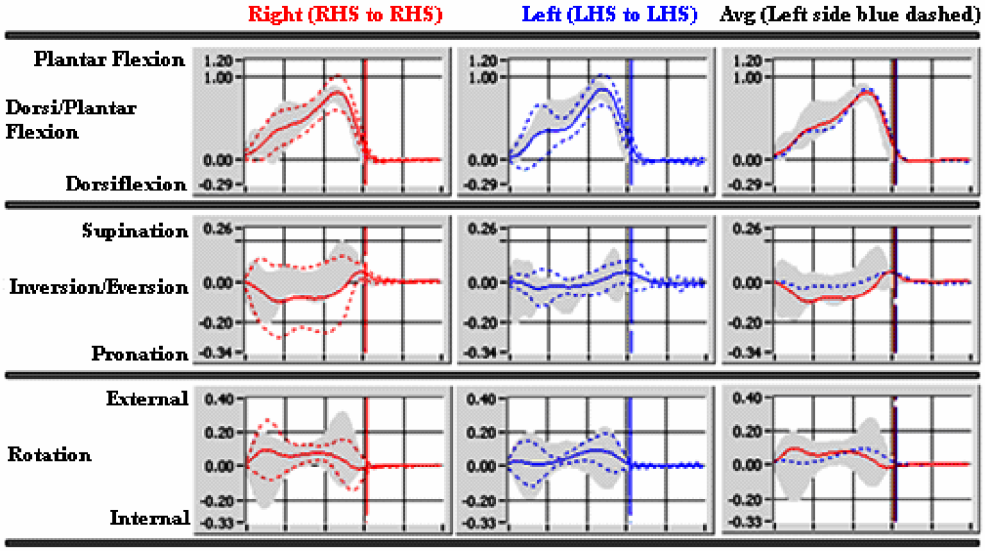

Figure 3.41 Ankle Joint Moments (Nm/kg), 4-year-old males.

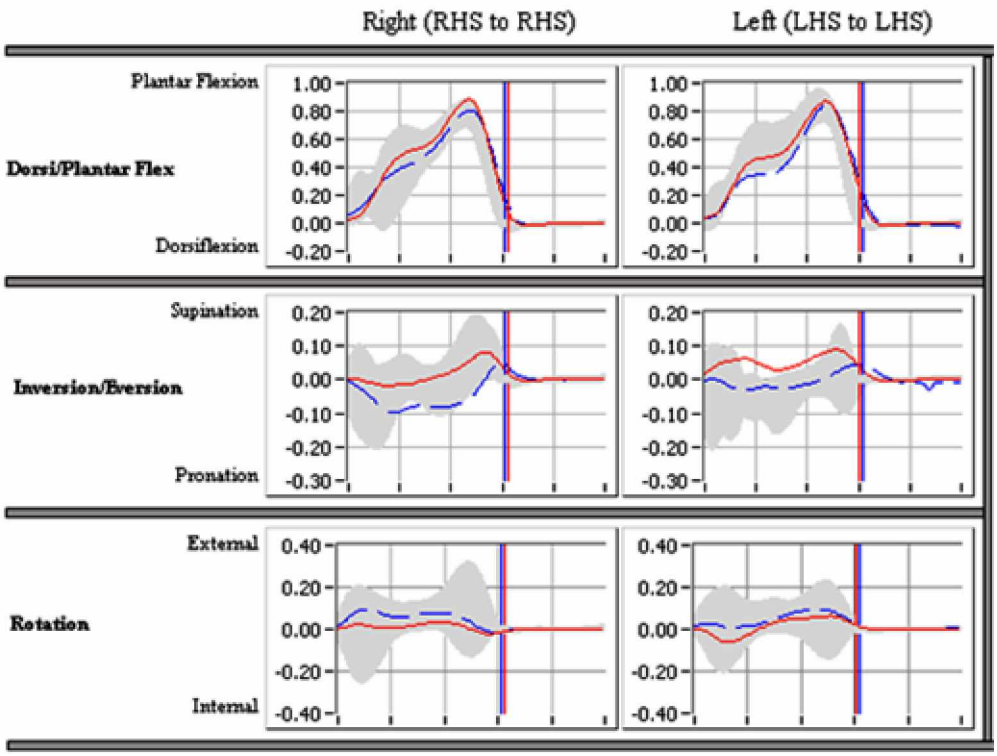

Figure 3.42 Ankle Joint Moments (Nm/Kg), 4-year-old subjects.

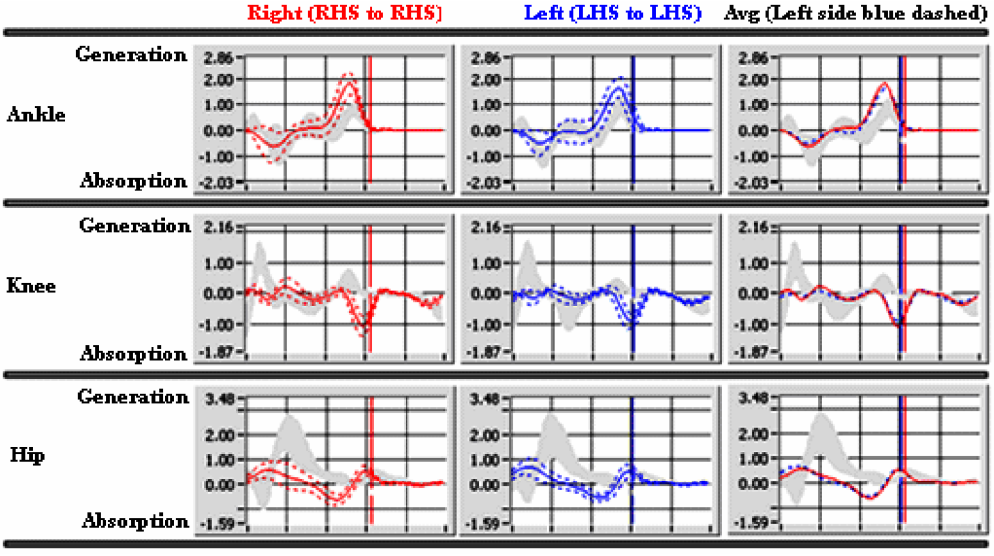

Figure 3.43 Sagittal Joint Powers (Watts/Kg), 4-year-old females.

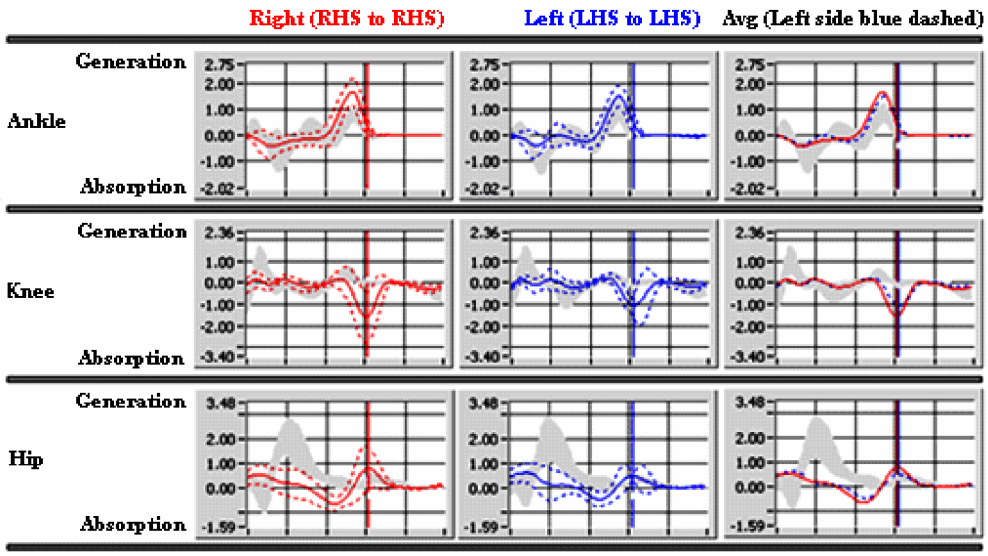

Figure 3.44 Sagittal Joint Powers (Watts/kg), 4-year-old males.

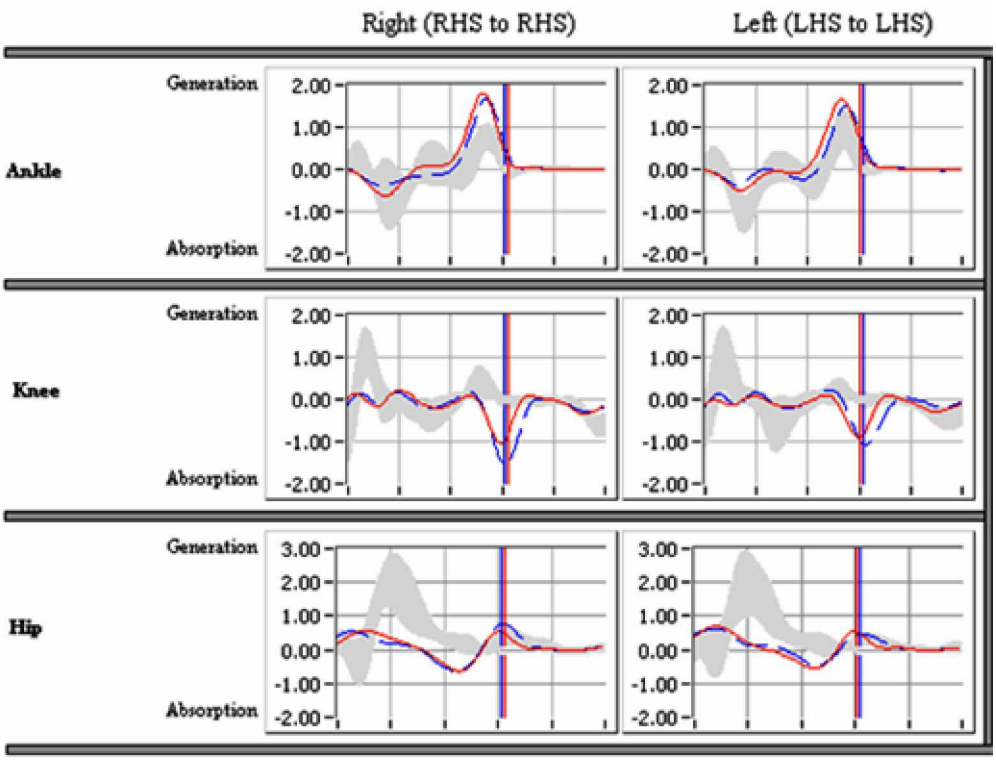

Figure 3.45 Sagittal Joint Powers (Watts/Kg), 4-year-old subjects.

4. DISCUSSION AND CONCLUSION

The objective of this study was to form Turkish norms in gait analysis. Norm curves of nine age groups were formed. Means, standard deviations and ranges were calculated for 15 parameters in basic gait parameters, for 32 parameters in kinematics and for 48 parameters in kinetics. 86 graphs for each age group for trunk and for both lower extremities were plotted as graphical outputs of the system. This allows a subjective comparison, as an additional outcome of this study. The tables and graphs show the norms of female and male subjects separately. All the parameters were presented in tables. A huge number of data, each of which deserves detailed exploration, was obtained in this study. It would be more convenient to examine each of these parameters individually. In the literature, there have been quite a number of studies about normative data. In these studies, parameters for each joint were examined separately, in different studies. For example, in a study, basic gait parameters were examined according to sex, age, etc [34]. In another study, kinematics and kinetic data of any one joint were examined [37, 39]. Therefore, a better understanding of joint motions can be achieved by evaluating each joint in a more detailed way. Such more detailed studies are indicated as future work.

It may be discussed that whether there was a need for norms of Turkish population. While forming normal curves in this study, the curves for females and males in each age group were plotted separately in the same graph with a gray band representing the gait analysis system's current normal band. By visual examination of the graphs, differences were found between the curves formed by Turkish children and the system's current normal band in kinematics and kinetic data concerning all three planes of movement, especially in transverse plane. Moreover, there were differences between females and males in the same age group. Even, some differences were found between gaits of nine-year-old aged twin boys. Because minute differences can cause very different results in gait analysis, the analysis of a person should be performed according to her/his population normal values in order to get more accurate and more reliable results. Besides, instrumented quantitative gait analyses have not been systematically adopted for the evaluation of gait in other populations. The data from one laboratory may differ in content, sensitivity to error, or reliability compared to the data from another. These differences

could be attributed to different camera resolutions and calibration, different corrections for lens non-linearities, different camera setups [36]. Therefore, for a gait laboratory, it should be necessary to have its own normative database.

In comparison studies of gait normative data between populations, it has been shown that there were statistically significant differences [33]. It was thought that a statistical comparison should be performed between outputs of this study and the system's current normative data. Therefore, a comparison was done in the evaluation of the gait analyses of twenty normal and ten children with Cerebral Palsy (Ten normal females, ten normal males, five females with Cerebral Palsy and five males with Cerebral Palsy). All the children included in this comparison were five-year-old age. The ten children with Cerebral Palsy had had their diagnoses prior to their gait analyses. The comparison was done by evaluating the kinematics data of hip, ankle and knee joints of the children according to these two normative databases with two standard deviations. Sensitivity values, specificity values, positive predictive values and negative predictive values of the two databases were calculated for six hip movements, six knee movements and six ankle movements. The tables of the results can be found in Appendix E. The comparative graphs of this comparison study are shown below in this section (Figures 4.1-12).

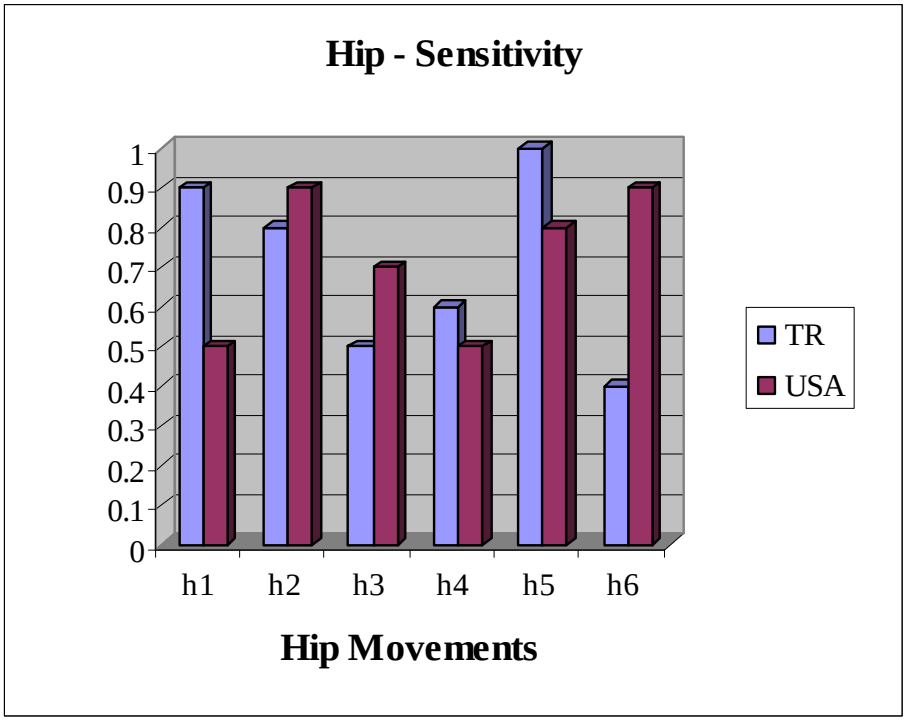

Figure 4.1 Comparative Sensitivity Graphs of Six Hip Movements

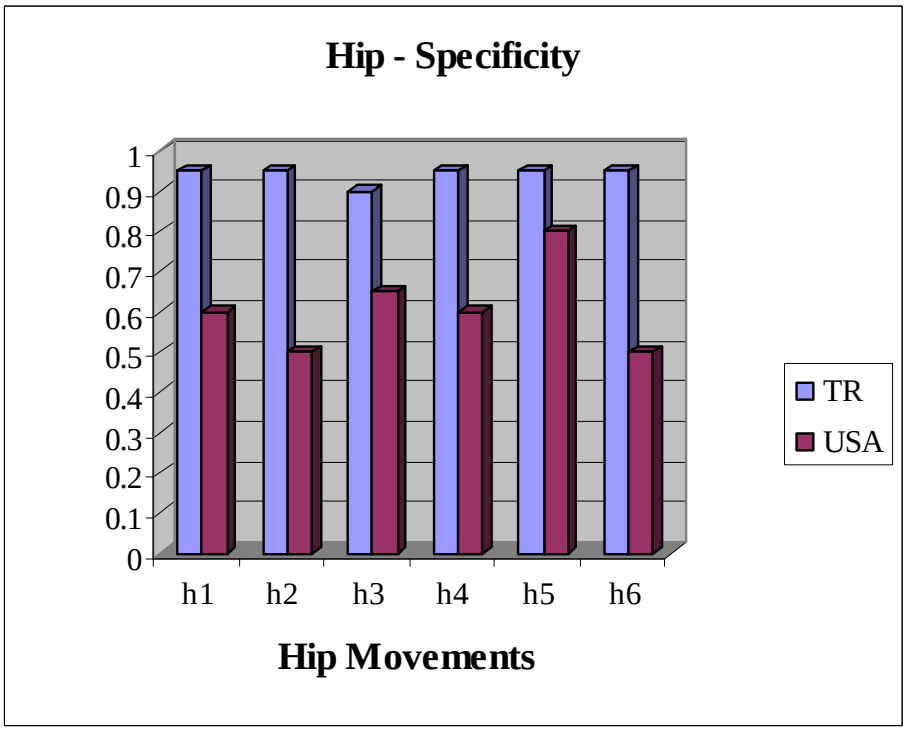

Figure 4.2 Comparative Specificity Graphs of Six Hip Movements

When statistical data of hip movements are examined (Figures 4.1-4), both reference tests are quite sensitive, with the exception of hip rotational movements (h3 and h6) for Turkish normative database. These low sensitivities in hip rotational movements can be attributed to the large variation of Turkish children in hip rotation movements. Although system's current normative database (USA) seems more sensitive than the Turkish normative database (TR), positive predictive values of USA are quite lower than of TR. TR is more specific in all hip movements. These data can be interpreted as USA has a greater tendency to predict normal hip movements as abnormal. This leads to greater sensitivity, but less specificity and lower positive predictive values.

When statistical data of knee movements are examined, USA is more sensitive but much less specific than TR. Additionally, USA have much lower positive predictive values than TR. In other words, USA has a greater tendency to predict normal knee movements as abnormal. Even, USA should not be accepted as reference database in left knee tibial torsion movement (k6), because it is not specific at all, has quite low positive predictive value, and an indeterminate negative predictive value that was accepted as zero.

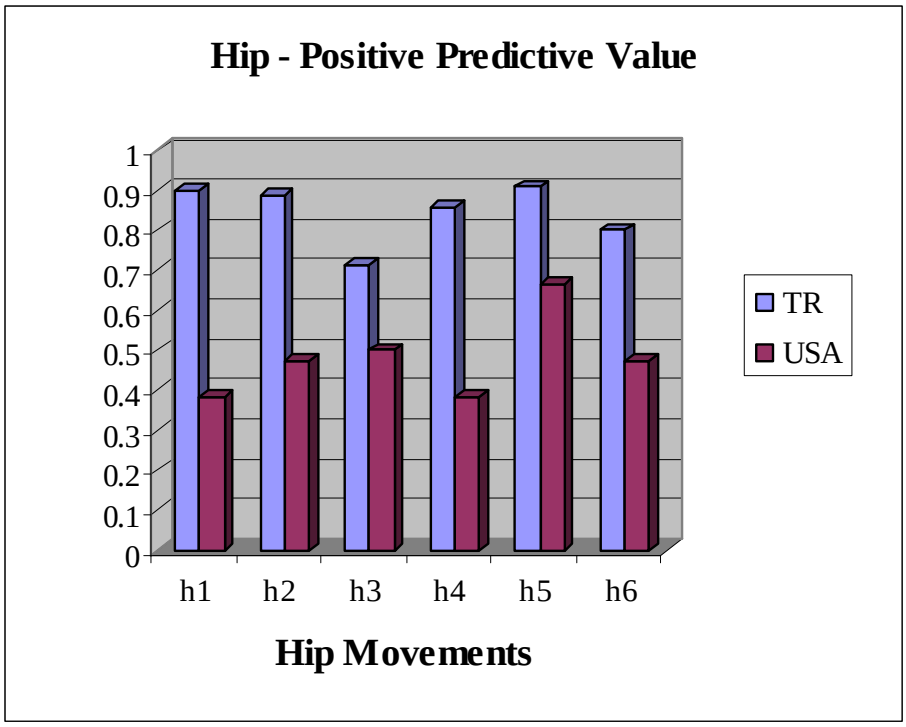

Figure 4.3 Comparative Positive Predictive Value Graphs of Six Hip Movements

When statistical data of ankle movements are examined (Figures 4.9-12), USA is more sensitive than TR. However, USA is not specific at all for the ankle movements of Turkish population, whereas TR is quite specific. TR has high positive predictive and high negative predictive values in all ankle movements, but USA has quite low positive and quite low negative predictive values in all ankle movements. Moreover, USA has indeterminate negative predictive values for all ankle movements except right ankle flexion/extension movement. This is a very important and valuable outcome of this statistical analysis.

When all the statistical data for all the movements in hip, knee and ankle joints are examined, USA can be accepted as more sensitive than TR. However, it is very useful to state that all the joint movements of subjects with Cerebral Palsy in this study were theoretically accepted as abnormal although, most probably, not all of them were abnormal. This should explain why USA seems more sensitive. Additionally, when the graphs for positive and negative predictive values are examined, USA database cannot be accepted as a proper reference data in the evaluation of hip, knee and ankle joint movements of Turkish population. These results also suggest that precise evaluation of a gait disorder needs to be done by comparing the patient with her/his own population.

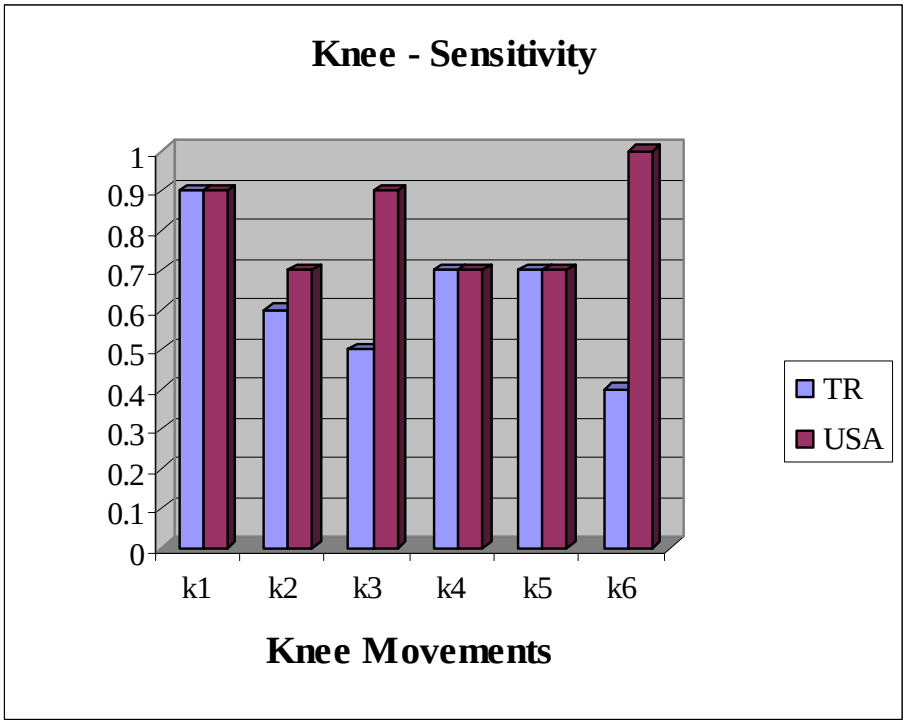

Figure 4.5 Comparative Sensitivity Graphs of Six Knee Movements

According to the results obtained from the statistical analysis in this section, it can be inferred that the system's current normative database is not a proper and reliable reference data for Turkish population. In addition, the results support the strong need for a proper and reliable reference data.

When all the graphs of statistical analysis are examined, it can be interpreted that Turkish normative database can serve as a sensitive, specific and reliable reference data for Turkish population in hip, knee and ankle movements.

As a conclusion, it can safely be stated that this study achieved its main objective: The database obtained presently can serve as a reference data of Turkish population in gait analysis. Besides, this study will provide the data for many other required studies concerning gait analysis in Turkish population. Further studies can be about influence of age and sex, and comparison of Turkish population with other populations in gait analysis.

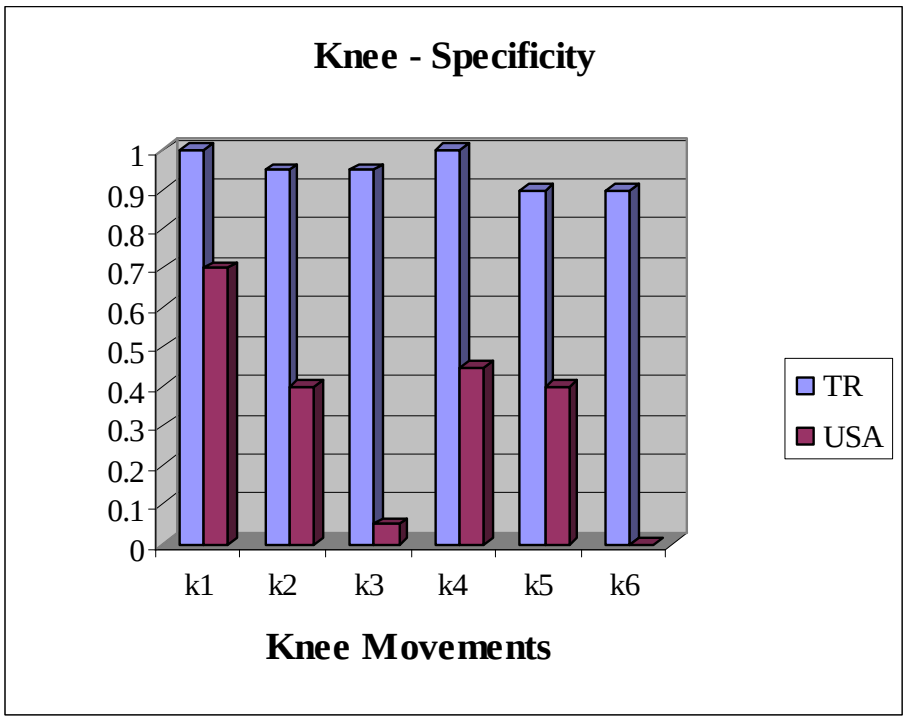

Figure 4.6 Comparative Specificity Graphs of Six Knee Movements

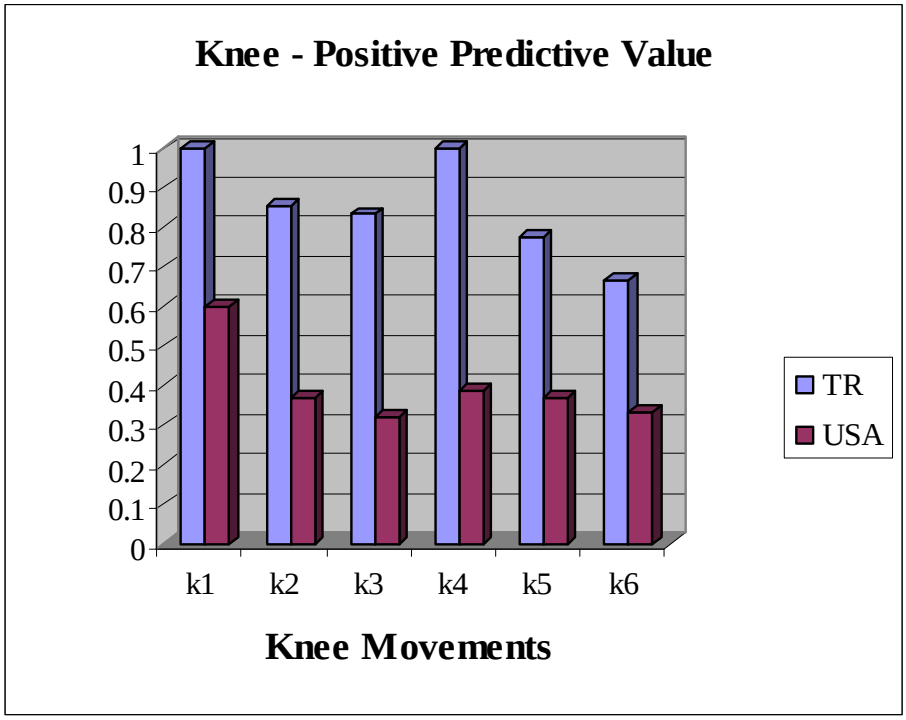

Figure 4.7 Comparative Positive Predictive Value Graphs of Six Knee Movements

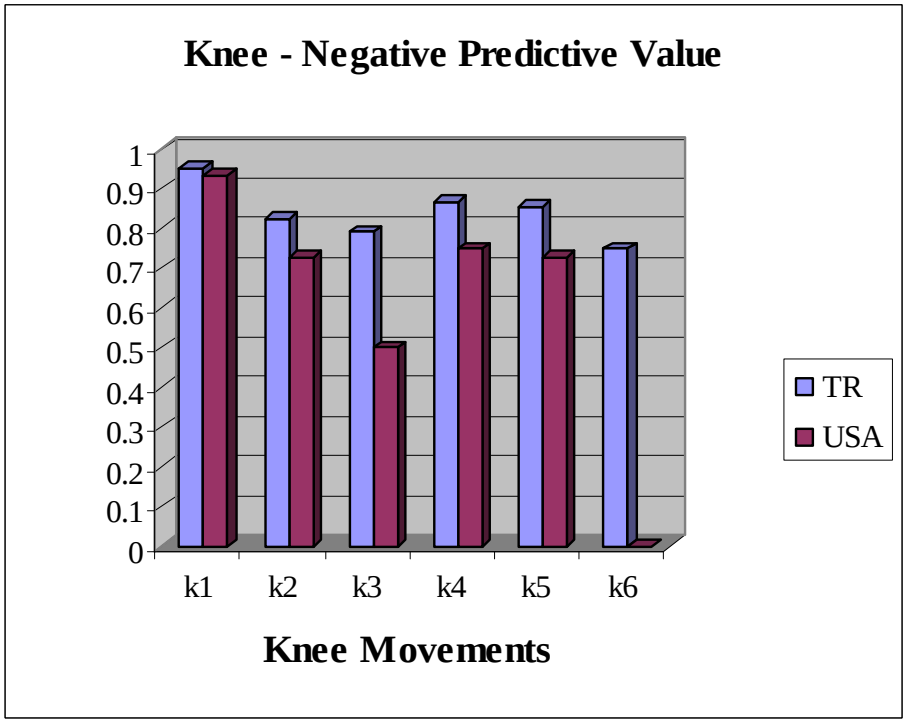

Figure 4.8 Comparative Negative Predictive Value Graphs of Six Knee Movements. Negative Predictive Value of the reference database USA for k6 is indeterminate (0/0), and it was accepted as zero.

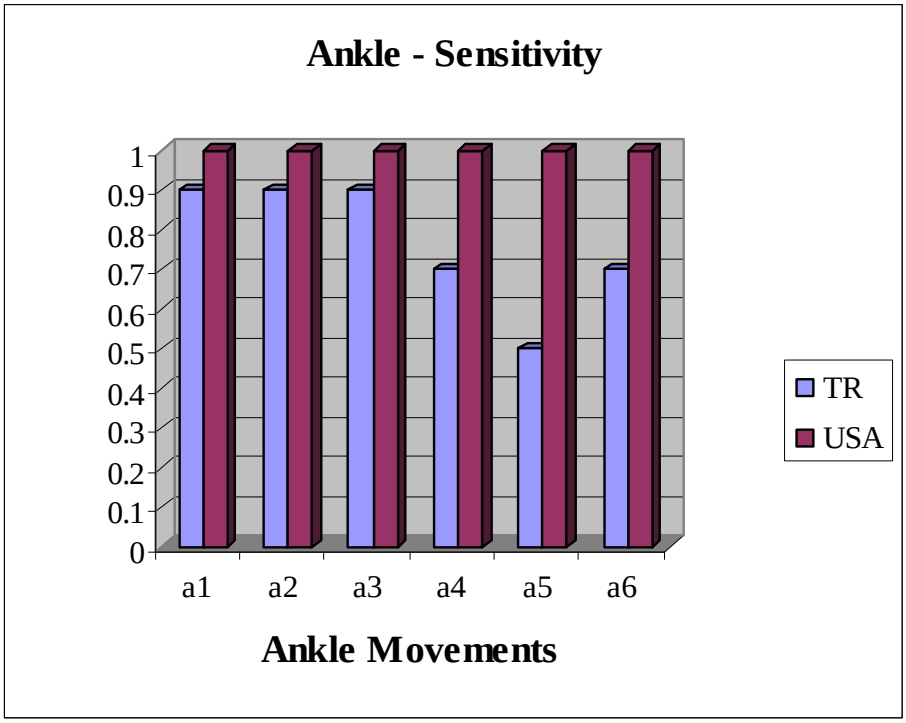

Figure 4.9 Comparative Sensitivity Graphs of Six Ankle Movements

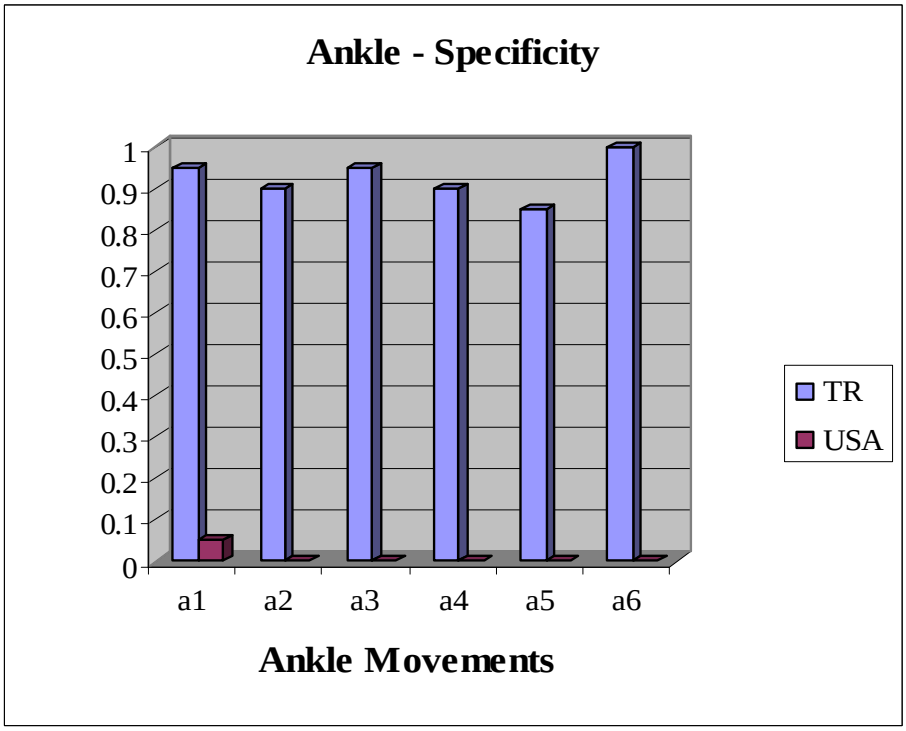

Figure 4.10 Comparative Specificity Graphs of Six Ankle Movements

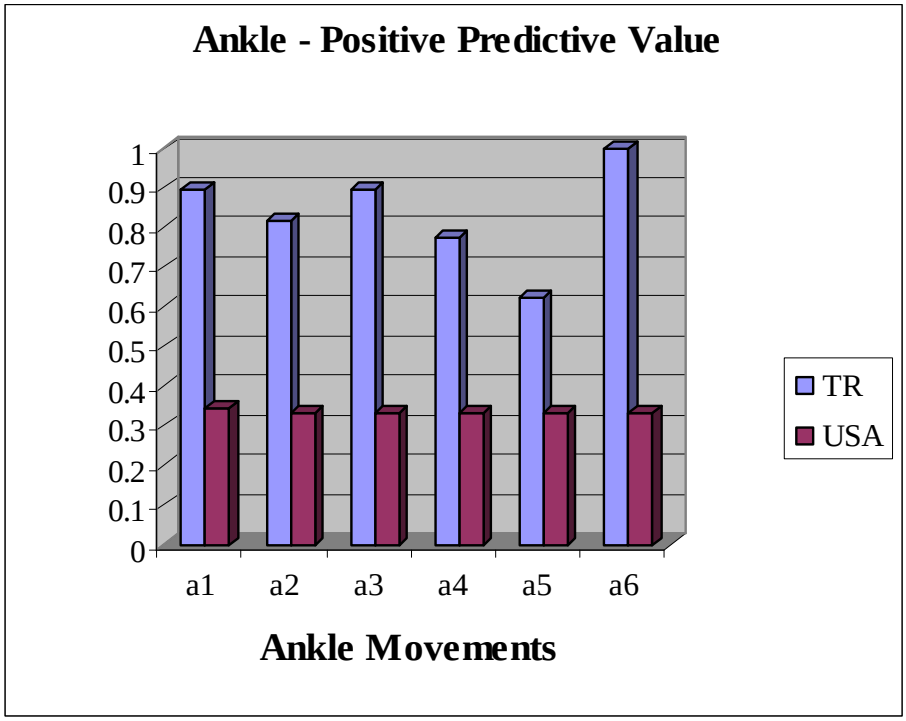

Figure 4.11 Comparative Positive Predictive Value Graphs of Six Ankle Movements

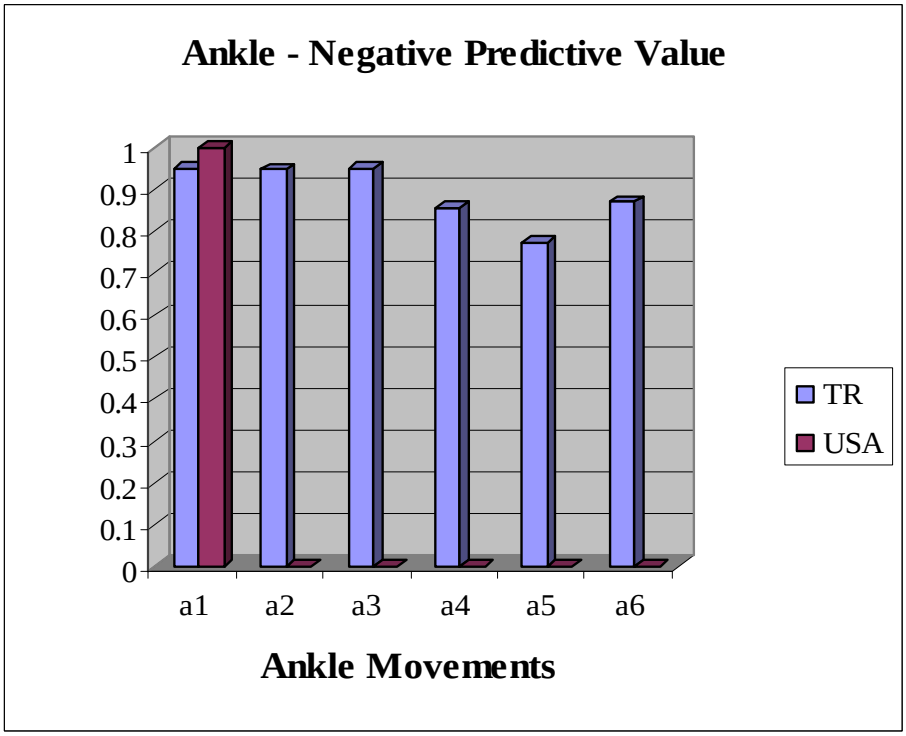

Figure 4.12 Comparative Negative Predictive Value Graphs of Six Ankle Movements. Negative Predictive Values of the reference database USA for a2, a3, a4, a5 and a6 were indeterminate (0/0), and they were accepted as zero.

APPENDIX A

BASIC GAIT PARAMETERS

Table A.1 Basic Gait Parameters of 5-year-old Subjects
(SD: Standard Deviation, 'R' stands for right side, 'L' stands for left side, 'Dbl' stands for double.)

	Females				**Males**			
	Mean	SD	Mean+SD	Mean–SD	Mean	SD	Mean+SD	Mean–SD
Step Width (cm)	7.79	0.88	8.67	6.91	8.06	1.62	9.69	6.44
R_Velocity (cm/s)	116.66	13.52	130.17	103.14	113.34	13.16	126.50	100.19
R_Stride Length (cm)	93.10	7.27	100.37	85.83	93.57	8.54	102.11	85.03
R_Cadence (steps/min)	150.12	10.50	160.61	139.62	145.10	10.71	155.82	134.39
L_Velocity (cm/s)	116.51	14.08	130.59	102.43	113.34	13.42	126.76	99.92
L_Stride Length (cm)	93.09	7.87	100.96	85.23	93.54	8.44	101.99	85.10
L_Cadence (steps/min)	149.76	10.39	160.15	139.37	145.25	11.36	156.61	133.89
R_Stance Phase (%)	60.38	1.52	61.90	58.85	60.95	1.36	62.31	59.59
L_Stance Phase (%)	60.30	1.29	61.59	59.02	60.55	1.14	61.69	59.41
R_Swing Phase (%)	39.62	1.52	41.15	38.10	39.05	1.36	40.41	37.69
L_Swing Phase (%)	39.70	1.29	40.98	38.41	39.45	1.14	40.59	38.31
R_Step_Length (cm)	46.27	3.85	50.12	42.43	47.02	4.47	51.48	42.55
L_Step_Length (cm)	46.74	4.05	50.79	42.70	46.43	4.13	50.56	42.29
R_Dbl_Support Time (%)	10.20	1.14	11.34	9.06	10.76	0.92	11.69	9.84
L_Dbl_Support Time (%)	10.21	0.97	11.18	9.24	10.75	1.02	11.77	9.73
Right Heel Strike (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Left Heel Strike (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right Toe Off (%)	60.38	1.52	61.90	58.85	60.95	1.36	62.31	59.59
Left Toe Off (%)	60.30	1.29	61.59	59.02	60.55	1.14	61.69	59.41

Table A.2 Basic Gait Parameters of 7-year-old Subjects
(SD: Standard Deviation, 'R' stands for right side, 'L' stands for left side, 'Dbl' stands for double.)

	Females				**Males**			
	Mean	SD	Mean+SD	Mean–SD	Mean	SD	Mean+SD	Mean–SD
Step Width (cm)	7.13	1.16	8.29	5.98	9.20	0.94	10.14	8.26
R_Velocity (cm/s)	117.79	10.72	128.51	107.07	115.76	9.08	124.84	106.67
R_Stride Length (cm)	99.30	9.35	108.65	89.95	99.54	6.27	105.80	93.27
R_Cadence (steps/min)	142.50	10.06	152.56	132.44	139.40	7.85	147.25	131.55
L_Velocity (cm/s)	118.04	12.02	130.06	106.02	115.64	8.80	124.44	106.83
L_Stride Length (cm)	99.62	9.76	109.38	89.87	99.49	5.92	105.41	93.58
L_Cadence (steps/min)	142.34	10.13	152.47	132.21	139.51	7.89	147.41	131.62
R_Stance Phase (%)	60.03	1.21	61.23	58.82	60.64	1.10	61.74	59.55
L_Stance Phase (%)	59.73	1.20	60.94	58.53	61.14	1.08	62.22	60.06
R_Swing Phase (%)	39.97	1.21	41.18	38.77	39.36	1.10	40.45	38.26
L_Swing Phase (%)	40.27	1.20	41.47	39.06	38.86	1.08	39.94	37.78
R_Step_Length (cm)	49.30	4.36	53.67	44.94	49.94	3.22	53.16	46.71
L_Step_Length (cm)	49.93	5.25	55.18	44.69	49.57	3.13	52.70	46.44
R_Dbl_Support Time (%)	9.81	1.22	11.03	8.58	10.83	1.07	11.90	9.77
L_Dbl_Support Time (%)	9.79	1.31	11.10	8.48	10.99	0.98	11.98	10.01
Right Heel Strike (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Left Heel Strike (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right Toe Off (%)	60.03	1.21	61.23	58.82	60.64	1.10	61.74	59.55
Left Toe Off (%)	59.73	1.20	60.94	58.53	61.14	1.08	62.22	60.06

Table A.3 Basic Gait Parameters of 8-year-old Subjects
(SD: Standard Deviation, 'R' stands for right side, 'L' stands for left side, 'Dbl' stands for double.)

	Females				**Males**			
	Mean	SD	Mean+SD	Mean–SD	Mean	SD	Mean+SD	Mean–SD
Step Width (cm)	8.38	2.06	10.45	6.32	8.70	1.36	10.06	7.34
R_Velocity (cm/s)	113.05	13.65	126.70	99.40	115.17	6.79	121.96	108.39
R_Stride Length (cm)	104.14	10.54	114.68	93.61	102.32	4.83	107.15	97.49
R_Cadence (steps/min)	130.15	6.36	136.51	123.79	135.14	4.73	139.87	130.40
L_Velocity (cm/s)	114.06	13.76	127.83	100.30	115.75	7.17	122.92	108.58
L_Stride Length (cm)	104.58	10.99	115.56	93.59	102.49	5.43	107.92	97.05
L_Cadence (steps/min)	130.65	6.06	136.72	124.59	135.52	4.69	140.21	130.82
R_Stance Phase (%)	61.21	0.91	62.13	60.30	60.64	0.86	61.51	59.78
L_Stance Phase (%)	60.80	1.22	62.01	59.58	60.83	0.95	61.78	59.88
R_Swing Phase (%)	38.79	0.91	39.70	37.87	39.36	0.86	40.22	38.49
L_Swing Phase (%)	39.20	1.22	40.42	37.99	39.17	0.95	40.12	38.22
R_Step_Length (cm)	51.61	6.17	57.79	45.44	51.31	2.11	53.42	49.20
L_Step_Length (cm)	52.74	4.99	57.73	47.75	51.00	2.96	53.96	48.04
R_Dbl_Support Time (%)	11.26	0.92	12.18	10.34	10.74	0.89	11.63	9.85
L_Dbl_Support Time (%)	10.88	1.03	11.91	9.85	10.66	0.77	11.43	9.89
Right Heel Strike (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Left Heel Strike (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right Toe Off (%)	61.21	0.91	62.13	60.30	60.64	0.86	61.51	59.78
Left Toe Off (%)	60.80	1.22	62.01	59.58	60.83	0.95	61.78	59.88

Table A.4 Basic Gait Parameters of 9-year-old Subjects
(SD: Standard Deviation, 'R' stands for right side, 'L' stands for left side, 'Dbl' stands for double.)

	Females				**Males**			
	Mean	SD	Mean+SD	Mean–SD	Mean	SD	Mean+SD	Mean–SD
Step Width (cm)	8.68	1.80	10.48	6.89	8.83	1.70	10.53	7.13
R_Velocity (cm/s)	112.30	14.28	126.59	98.02	115.17	6.66	121.83	108.51
R_Stride Length (cm)	104.60	8.11	112.70	96.49	105.81	5.65	111.46	100.15
R_Cadence (steps/min)	128.67	12.13	140.80	116.54	131.19	8.98	140.17	122.20
L_Velocity (cm/s)	112.94	14.91	127.85	98.03	115.60	7.25	122.84	108.35
L_Stride Length (cm)	104.95	8.69	113.64	96.26	105.76	5.86	111.62	99.90
L_Cadence (steps/min)	129.09	12.11	141.20	116.98	131.39	9.10	140.50	122.29
R_Stance Phase (%)	60.91	1.35	62.26	59.56	60.87	0.99	61.86	59.88
L_Stance Phase (%)	60.47	1.00	61.47	59.47	60.72	0.96	61.68	59.76
R_Swing Phase (%)	39.09	1.35	40.44	37.74	39.13	0.99	40.12	38.14
L_Swing Phase (%)	39.53	1.00	40.53	38.53	39.28	0.96	40.24	38.32
R_Step_Length (cm)	52.15	3.96	56.11	48.19	52.72	2.67	55.39	50.05
L_Step_Length (cm)	52.53	4.75	57.28	47.78	53.00	3.43	56.43	49.57
R_Dbl_Support Time (%)	10.71	0.95	11.66	9.76	10.82	0.94	11.75	9.88
L_Dbl_Support Time (%)	10.67	1.26	11.93	9.41	10.90	1.11	12.00	9.79
Right Heel Strike (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Left Heel Strike (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right Toe Off (%)	60.91	1.35	62.26	59.56	60.87	0.99	61.86	59.88
Left Toe Off (%)	60.47	1.00	61.47	59.47	60.72	0.96	61.68	59.76

Table A.5 Basic Gait Parameters of 16-year-old Subjects
(SD: Standard Deviation, 'R' stands for right side, 'L' stands for left side, 'Dbl' stands for double.)

	Females				**Males**			
	Mean	SD	Mean+SD	Mean–SD	Mean	SD	Mean+SD	Mean–SD
Step Width (cm)	8.74	2.07	10.81	6.67	12.12	4.23	16.35	7.89
R_Velocity (cm/s)	114.74	15.87	130.61	98.88	112.29	7.3	119.59	104.98
R_Stride Length (cm)	125.21	11.04	136.26	114.17	126.79	7.01	133.80	119.79
R_Cadence (steps/min)	109.30	7.34	116.64	101.96	106.33	5.72	112.05	100.61
L_Velocity (cm/s)	114.28	15.82	130.10	98.46	113.06	7.57	120.63	105.49
L_Stride Length (cm)	125.37	10.99	136.36	114.37	127.67	6.59	134.26	121.09
L_Cadence (steps/min)	109.07	7.29	116.36	101.79	106.48	5.61	112.09	100.87
R_Stance Phase (%)	61.66	1.49	63.14	60.17	61.27	0.80	62.07	60.48
L_Stance Phase (%)	60.95	1.51	62.46	59.44	61.04	0.53	61.56	60.51
R_Swing Phase (%)	38.34	1.49	39.83	36.86	38.73	0.83	39.52	37.93
L_Swing Phase (%)	39.05	1.51	40.56	37.54	38.96	0.53	39.49	38.44
R_Step_Length (cm)	63.06	5.59	68.65	57.46	64.36	3.33	67.69	61.03
L_Step_Length (cm)	62.07	5.56	67.63	56.51	63.10	3.87	66.97	59.23
R_Dbl_Support Time (%)	11.31	1.32	12.64	9.99	11.41	0.52	11.92	10.89
L_Dbl_Support Time (%)	11.06	1.33	12.39	9.73	11.22	0.72	11.94	10.49
Right Heel Strike (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Left Heel Strike (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right Toe Off (%)	61.66	1.49	63.14	60.17	61.27	0.83	62.07	60.48
Left Toe Off (%)	60.95	1.51	62.46	59.44	61.04	0.53	61.56	60.51

Table A.6 Basic Gait Parameters of 17-year-old Subjects
(SD: Standard Deviation, 'R' stands for right side, 'L' stands for left side, 'Dbl' stands for double.)

	Females				**Males**			
	Mean	SD	Mean+SD	Mean–SD	Mean	SD	Mean+SD	Mean–SD
Step Width (cm)	10.99	1.63	12.62	9.36	13.10	2.95	16.04	10.15
R_Velocity (cm/s)	116.06	12.1	128.17	103.96	115.69	11.61	127.3	104.08
R_Stride Length (cm)	124.83	9.37	134.2	115.46	129.02	6.8	135.82	122.22
R_Cadence (steps/min)	111.02	7.73	118.75	103.29	106.95	6.47	113.41	100.48
L_Velocity (cm/s)	116.46	11.90	128.36	104.56	115.36	11.78	127.14	103.58
L_Stride Length (cm)	126.04	8.95	134.99	117.09	129.33	6.38	135.72	122.95
L_Cadence (steps/min)	110.59	7.53	118.12	103.07	106.67	6.36	113.03	100.30
R_Stance Phase (%)	60.71	1.35	62.05	59.36	61.38	1.33	62.71	60.06
L_Stance Phase (%)	60.73	1.16	61.89	59.57	61.15	1.28	62.43	59.86
R_Swing Phase (%)	39.29	1.35	40.64	37.95	38.62	1.33	39.94	37.29
L_Swing Phase (%)	39.27	1.16	40.43	38.11	38.85	1.28	40.14	37.57
R_Step_Length (cm)	63.42	4.64	68.06	58.79	65.17	3.45	68.62	61.72
L_Step_Length (cm)	61.99	4.91	66.89	57.08	64.18	3.51	67.69	60.67
R_Dbl_Support Time (%)	10.66	1.10	11.76	9.57	11.12	1.60	12.73	9.52
L_Dbl_Support Time (%)	10.86	1.04	11.9	9.82	11.44	1.47	12.91	9.96
Right Heel Strike (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Left Heel Strike (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right Toe Off (%)	60.71	1.35	62.05	59.36	61.38	1.33	62.71	60.06
Left Toe Off (%)	60.73	1.16	61.89	59.57	61.15	1.28	62.43	59.86

Table A.7 Basic Gait Parameters of 18-year-old Subjects
(SD: Standard Deviation, 'R' stands for right side, 'L' stands for left side, 'Dbl' stands for double.)

	Females				**Males**			
	Mean	SD	Mean+SD	Mean–SD	Mean	SD	Mean+SD	Mean–SD
Step Width (cm)	9.62	2.20	11.82	7.42	12.70	3.24	15.94	9.46
R_Velocity (cm/s)	113.74	8.61	122.35	105.13	115.68	12.42	128.10	103.26
R_Stride Length (cm)	124.70	9.03	133.73	115.67	125.46	9.98	135.44	115.47
R_Cadence (steps/min)	109.14	5.75	114.90	103.39	110.15	5.96	116.10	104.19
L_Velocity (cm/s)	113.53	8.45	121.98	105.08	115.72	12.55	128.27	103.17
L_Stride Length (cm)	125.11	8.40	133.51	116.71	126.06	10.00	136.06	116.06
L_Cadence (steps/min)	108.58	5.73	114.31	102.85	109.86	5.82	115.68	104.04
R_Stance Phase (%)	60.95	0.72	61.67	60.23	61.85	1.06	62.91	60.79
L_Stance Phase (%)	60.23	0.89	61.12	59.33	61.63	0.81	62.44	60.83
R_Swing Phase (%)	39.05	0.72	39.77	38.33	38.15	1.06	39.21	37.09
L_Swing Phase (%)	39.77	0.89	40.67	38.88	38.37	0.81	39.17	37.56
R_Step_Length (cm)	62.51	4.46	66.97	58.05	63.02	5.25	68.27	57.77
L_Step_Length (cm)	62.31	4.69	67.00	57.62	62.58	4.78	67.36	57.80
R_Dbl_Support Time (%)	10.43	0.75	11.17	9.68	11.61	0.90	12.50	10.71
L_Dbl_Support Time (%)	10.59	0.80	11.39	9.79	11.69	1.33	13.02	10.35
Right Heel Strike (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Left Heel Strike (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right Toe Off (%)	60.95	0.72	61.67	60.23	61.85	1.06	62.91	60.79
Left Toe Off (%)	60.23	0.89	61.12	59.33	61.63	0.81	62.44	60.83

Table A.8 Basic Gait Parameters of 20-year-old Subjects
(SD: Standard Deviation, 'R' stands for right side, 'L' stands for left side, 'Dbl' stands for double.)

	Females				**Males**			
	Mean	SD	Mean+SD	Mean–SD	Mean	SD	Mean+SD	Mean–SD
Step Width (cm)	11.19	2.59	13.78	8.60	12.40	3.00	15.40	9.40
R_Velocity (cm/s)	121.79	5.05	126.83	116.74	118.16	12.71	130.87	105.45
R_Stride Length (cm)	127.73	4.03	131.76	123.70	127.17	10.20	137.37	116.98
R_Cadence (steps/min)	114.41	6.50	120.91	107.91	110.96	8.46	119.42	102.50
L_Velocity (cm/s)	121.44	5.36	126.80	116.08	118.37	13.01	131.38	105.36
L_Stride Length (cm)	128.18	4.38	132.56	123.81	127.99	10.46	138.44	117.53
L_Cadence (steps/min)	114.02	6.72	120.74	107.30	110.83	8.49	119.32	102.34
R_Stance Phase (%)	61.34	1.00	62.34	60.34	61.57	0.91	62.48	60.66
L_Stance Phase (%)	60.82	0.72	61.54	60.10	61.46	0.74	62.20	60.71
R_Swing Phase (%)	38.66	1.00	39.66	37.66	38.43	0.91	39.34	37.52
L_Swing Phase (%)	39.18	0.72	39.90	38.46	38.54	0.74	39.29	37.80
R_Step_Length (cm)	64.95	2.18	67.12	62.77	64.53	4.40	68.93	60.12
L_Step_Length (cm)	62.98	2.61	65.59	60.37	62.84	6.12	68.95	56.72
R_Dbl_Support Time (%)	10.90	0.90	11.80	9.99	11.31	1.03	12.34	10.28
L_Dbl_Support Time (%)	11.21	1.22	12.43	9.99	11.55	0.87	12.42	10.67
Right Heel Strike (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Left Heel Strike (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right Toe Off (%)	61.34	1.00	62.34	60.34	61.57	0.91	62.48	60.66
Left Toe Off (%)	60.82	0.72	61.54	60.10	61.46	0.74	62.20	60.71

APPENDIX B

KINEMATICS – Five-Year-Old Subjects

Table B.1 Stance Phase Kinematics of 5-year-old Female Subjects
(Max.= Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Foot Strike		**Maximum Stance**		**Time of Max. St.**		**Minimum Stance**		**Time of Min. St.**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-8.71	8.10	6.52	5.48	38.67	17.67	-8.71	8.10	0.00	0.00
L_Hip_Rot_Ang	-3.30	12.21	8.74	12.14	29.56	16.53	-3.30	12.21	0.00	0.00
R_Hip_Abd_Ang	2.19	3.94	11.22	2.59	20.00	2.35	-2.02	3.07	52.78	19.87
L_Hip_Abd_Ang	-1.23	2.08	7.40	1.72	20.33	1.66	-5.57	3.05	53.22	19.97
R_Hip_Flex_Ang	35.26	4.13	35.26	4.13	0.00	0.00	-14.42	5.83	52.78	1.48
L_Hip_Flex_Ang	35.18	6.23	35.18	6.23	0.00	0.00	-13.91	5.94	52.11	1.05
R_Knee_Rot_Ang	6.04	15.88	14.26	16.48	42.44	25.91	0.62	14.87	22.89	18.58
L_Knee_Rot_Ang	1.30	18.66	16.65	21.73	44.00	23.31	-2.18	19.35	21.67	20.94
R_Knee_Abd_Ang	-3.83	1.87	0.29	3.87	40.67	21.06	-4.55	2.04	24.22	27.81
L_Knee_Abd_Ang	-3.98	2.64	2.08	5.04	38.33	19.89	-5.68	3.23	40.11	24.06
R_Knee_Flex_Ang	8.81	5.76	29.29	4.10	59.33	1.73	1.41	4.80	36.22	13.02
L_Knee_Flex_Ang	7.73	7.84	30.92	6.45	49.67	20.51	-0.07	3.89	40.44	2.24
R_Ank_Rot_Ang	-15.43	10.21	-9.01	9.42	34.11	19.62	-27.69	10.38	12.89	1.17
L_Ank_Rot_Ang	-14.04	8.04	-8.41	6.46	37.89	14.95	-29.96	8.53	29.33	23.26
R_Ank_Abd_Ang	-1.97	1.47	-0.38	1.62	52.67	19.82	-5.75	3.29	23.22	10.84
L_Ank_Abd_Ang	-1.48	1.52	-0.34	1.19	44.56	24.66	-5.81	3.54	25.67	11.91
R_Ank_Flex_Ang	5.98	2.18	17.13	3.07	41.22	6.57	-0.09	4.68	52.89	19.16
L_Ank_Flex_Ang	4.66	3.82	16.91	2.88	41.78	4.87	1.16	3.51	46.67	24.79
R_Elbow_Ang	26.77	8.33	52.67	9.08	53.44	2.13	25.67	7.87	6.22	2.86
L_Elbow_Ang	22.74	5.29	50.71	12.58	54.33	3.04	21.75	5.56	5.67	2.78
R_Shl_Add_Ang	30.29	6.30	30.32	6.31	0.67	1.41	19.15	3.28	36.22	12.81
L_Shl_Add_Ang	27.87	5.45	28.18	5.43	7.78	17.04	18.18	5.12	36.00	13.70
R_Shl_Flex_Ang	-68.91	9.73	-4.01	19.34	49.33	1.58	-69.41	9.73	4.22	3.35
L_Shl_Flex_Ang	-71.21	12.17	0.09	18.47	50.89	1.76	-72.08	12.19	5.00	3.50
R_Trunk_Lat_Tilt	-1.16	1.64	1.09	2.20	50.89	18.70	-1.72	1.87	15.11	6.15
L_Trunk_Lat_Tilt	-1.16	1.64	1.09	2.23	51.11	18.80	-1.72	1.87	15.11	6.15
R_Trunk_Fwd_Tilt	-2.08	1.64	-1.26	2.04	31.67	18.24	-4.52	1.97	39.89	22.96
L_Trunk_Fwd_Tilt	-2.08	1.64	-1.26	2.04	31.67	18.24	-4.53	1.95	35.22	23.04
R_Trunk_Rotation	-1.77	3.81	5.40	3.62	49.78	8.21	-1.91	3.67	2.56	5.08
L_Trunk_Rotation	-1.77	3.81	5.32	3.62	49.22	7.50	-1.91	3.67	2.56	5.08
R_Pelvis_Lat_Tilt	2.98	2.64	6.79	2.40	16.22	1.72	-1.71	1.11	59.33	1.73
L_Pelvis_Lat_Tilt	2.98	2.64	6.79	2.40	16.22	1.72	-1.75	1.20	59.44	1.42
R_Pelvis_Fwd_Tilt	10.70	3.92	11.33	4.25	35.11	15.24	8.70	4.10	29.00	22.44
L_Pelvis_Fwd_Tilt	10.70	3.92	11.33	4.25	35.11	15.24	8.69	4.07	24.33	19.86
R_Pelvis_Rotation	9.07	2.49	9.62	2.17	5.00	5.02	-5.53	4.16	54.89	4.83
L_Pelvis_Rotation	9.07	2.49	9.62	2.17	5.00	5.02	-5.54	4.17	54.89	4.73
R_Foot_Orientation	-8.21	6.40	-3.24	7.43	17.22	2.77	-8.92	6.85	23.00	27.63
L_Foot_Orientation	-11.48	6.54	-6.36	7.21	35.11	21.36	-11.97	6.26	10.44	20.78

Table B.2 Swing Phase Kinematics of 5-year-old Female Subjects
(Max = Maximum, Sw. = Swing, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Maximum Swing		**Time of Max. Sw.**		**Minimum Swing**		**Time of Min. Sw.**		**Toe Off**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	3.63	6.43	68.11	11.39	-9.30	7.85	98.89	0.71	2.66	7.68
L_Hip_Rot_Ang	6.68	13.14	70.99	11.42	-4.23	11.82	92.88	11.62	4.58	13.79
R_Hip_Abd_Ang	1.71	3.38	97.33	5.43	-4.47	2.65	68.44	2.90	-2.30	3.00
L_Hip_Abd_Ang	-2.02	1.99	97.10	5.23	-7.90	2.66	67.54	2.03	-5.95	3.07
R_Hip_Flex_Ang	36.50	4.00	92.55	3.34	-9.28	6.16	60.44	1.60	-9.28	6.16
L_Hip_Flex_Ang	36.38	6.76	92.21	3.33	-7.68	7.02	60.32	1.36	-7.68	7.02
R_Knee_Rot_Ang	27.71	12.18	73.33	2.62	1.21	16.10	87.22	16.11	13.30	15.06
L_Knee_Rot_Ang	32.35	17.93	71.43	2.99	-1.41	17.59	94.21	3.31	17.32	22.42
R_Knee_Abd_Ang	2.91	6.10	85.11	5.52	-5.74	3.35	83.55	14.85	-1.44	5.47
L_Knee_Abd_Ang	6.03	9.20	83.10	8.53	-7.82	5.86	83.43	14.76	-1.00	8.23
R_Knee_Flex_Ang	68.14	6.10	74.55	1.26	8.45	5.70	99.11	0.30	32.71	4.15
L_Knee_Flex_Ang	67.66	6.74	73.88	0.94	7.26	7.04	98.88	0.20	34.29	6.71
R_Ank_Rot_Ang	-13.02	10.54	98.00	1.88	-37.58	9.45	77.00	1.87	-19.38	8.76
L_Ank_Rot_Ang	-12.73	8.49	97.88	1.65	-41.05	13.09	74.65	2.11	-24.34	12.54
R_Ank_Abd_Ang	1.03	1.81	68.00	9.59	-6.44	2.84	81.55	2.36	-0.05	1.68
L_Ank_Abd_Ang	0.18	1.71	66.99	10.56	-6.07	3.05	80.10	1.61	-0.46	1.46
R_Ank_Flex_Ang	9.23	1.47	86.77	3.63	-3.18	4.45	64.11	2.52	-1.12	4.78
L_Ank_Flex_Ang	8.41	3.01	86.43	4.99	-0.76	3.71	63.43	1.78	0.67	3.46
R_Elbow_Ang	50.64	9.59	60.44	1.60	26.71	8.18	99.11	0.30	50.64	9.59
L_Elbow_Ang	48.72	11.76	60.32	1.36	22.92	5.16	98.88	0.20	48.72	11.76
R_Shl_Add_Ang	30.21	6.19	99.11	0.30	19.27	2.80	70.89	3.23	21.30	2.22
L_Shl_Add_Ang	28.03	5.43	94.65	12.69	17.84	5.14	71.43	7.12	20.45	6.39
R_Shl_Flex_Ang	-12.67	17.46	60.44	1.60	-69.12	9.37	99.11	0.30	-12.67	17.46
L_Shl_Flex_Ang	-7.09	18.72	60.32	1.36	-71.02	11.59	97.88	2.90	-7.09	18.72
R_Trunk_Lat_Tilt	1.09	2.15	67.44	12.62	-1.35	1.71	97.77	3.88	0.98	2.17
L_Trunk_Lat_Tilt	1.10	2.14	67.21	12.40	-1.35	1.71	97.54	4.03	0.99	2.19
R_Trunk_Fwd_Tilt	-1.46	1.72	91.33	2.68	-4.63	1.88	64.00	2.54	-4.43	1.92
L_Trunk_Fwd_Tilt	-1.46	1.72	91.10	2.78	-4.63	1.88	63.76	2.70	-4.42	1.84
R_Trunk_Rotation	4.41	3.74	60.89	2.07	-2.32	3.90	92.44	4.85	4.39	3.75
L_Trunk_Rotation	4.34	3.72	61.32	1.37	-2.32	3.90	92.21	4.76	4.25	3.71
R_Pelvis_Lat_Tilt	2.45	2.29	95.66	5.45	-3.21	1.42	67.22	1.40	-2.01	1.15
L_Pelvis_Lat_Tilt	2.45	2.29	95.43	5.42	-3.21	1.42	66.99	1.38	-2.04	1.23
R_Pelvis_Fwd_Tilt	10.87	4.26	88.22	7.59	8.93	4.08	64.55	3.42	9.18	4.10
L_Pelvis_Fwd_Tilt	10.87	4.26	87.99	7.68	8.94	4.10	64.65	2.98	9.21	4.09
R_Pelvis_Rotation	8.68	2.84	99.11	0.30	-4.76	3.40	61.66	3.43	-4.72	3.43
L_Pelvis_Rotation	8.68	2.84	98.88	0.20	-4.77	3.44	61.54	3.48	-4.73	3.47
R_Foot_Orientation	-6.31	7.52	73.55	19.25	-16.27	6.91	81.11	9.56	-6.80	8.00
L_Foot_Orientation	-7.75	6.91	61.76	2.79	-17.73	6.05	84.99	3.21	-8.13	7.37

Table B.3 Stance Phase Kinematics of 5-year-old Male Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Foot Strike		**Maximum Stance**		**Time of Max. St.**		**Minimum Stance**		**Time of Min. St.**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-9.15	9.18	5.02	9.20	41.67	15.21	-9.15	9.18	0.00	0.00
L_Hip_Rot_Ang	-5.68	9.67	7.49	8.89	36.78	12.89	-5.68	9.67	0.00	0.00
R_Hip_Abd_Ang	-0.73	3.28	8.01	2.82	23.00	3.35	-4.12	2.50	46.56	26.42
L_Hip_Abd_Ang	-0.19	2.23	7.81	1.96	23.00	1.87	-4.26	4.11	52.67	19.79
R_Hip_Flex_Ang	33.09	5.76	33.09	5.76	0.00	0.00	-14.53	7.87	53.44	1.13
L_Hip_Flex_Ang	31.80	6.73	31.80	6.73	0.00	0.00	-14.44	8.04	53.00	1.32
R_Knee_Rot_Ang	7.57	11.74	16.56	9.18	37.78	26.92	0.77	7.28	40.00	7.60
L_Knee_Rot_Ang	6.58	12.97	18.87	10.16	42.00	26.50	0.13	10.28	25.89	24.27
R_Knee_Abd_Ang	-3.39	2.37	1.74	3.78	27.00	17.12	-3.99	2.32	17.00	23.81
L_Knee_Abd_Ang	-3.31	2.07	1.98	2.86	30.44	21.46	-4.04	1.55	24.67	28.54
R_Knee_Flex_Ang	8.98	5.82	32.80	5.65	60.00	1.32	3.34	5.62	33.22	18.35
L_Knee_Flex_Ang	6.07	5.47	30.55	5.83	59.44	1.33	2.14	6.39	32.89	18.44
R_Ank_Rot_Ang	-18.12	6.79	-10.27	6.35	39.78	15.26	-32.00	8.63	19.89	15.47
L_Ank_Rot_Ang	-14.99	10.64	-7.69	7.57	31.11	23.45	-30.56	13.54	19.67	15.17
R_Ank_Abd_Ang	-2.93	1.20	0.03	1.95	58.33	4.80	-6.85	3.00	26.00	10.95
L_Ank_Abd_Ang	-2.16	1.88	-0.11	1.79	51.89	19.06	-5.81	3.66	25.00	9.23
R_Ank_Flex_Ang	8.41	2.23	16.88	4.24	41.33	5.32	0.40	5.77	53.89	18.00
L_Ank_Flex_Ang	6.50	3.46	15.45	3.76	40.33	4.33	-0.15	4.12	59.44	1.33
R_Elbow_Ang	27.96	6.13	53.59	7.92	53.00	2.50	26.35	5.43	7.44	3.47
L_Elbow_Ang	29.81	6.14	52.18	12.14	54.00	2.12	28.68	5.55	7.11	3.30
R_Shl_Add_Ang	30.53	3.45	30.66	3.47	1.33	2.24	20.61	4.56	36.33	10.95
L_Shl_Add_Ang	29.80	5.01	30.13	5.09	7.89	17.78	21.69	4.35	34.67	11.64
R_Shl_Flex_Ang	-69.03	8.78	-8.02	31.08	49.56	3.05	-70.03	8.53	4.67	4.12
L_Shl_Flex_Ang	-63.31	13.33	-4.80	21.04	50.67	2.60	-63.90	13.55	3.11	3.37
R_Trunk_Lat_Tilt	-1.04	1.69	1.94	1.53	56.44	6.97	-1.84	1.78	12.44	6.98
L_Trunk_Lat_Tilt	-1.04	1.69	1.92	1.52	56.00	6.67	-1.84	1.78	12.44	6.98
R_Trunk_Fwd_Tilt	-0.67	1.78	-0.05	1.52	41.22	2.86	-3.09	1.81	45.33	21.66
L_Trunk_Fwd_Tilt	-0.67	1.78	-0.05	1.52	41.22	2.86	-3.07	1.81	45.22	21.57
R_Trunk_Rotation	-0.37	2.39	5.64	1.54	51.78	9.87	-0.55	2.27	3.67	4.95
L_Trunk_Rotation	-0.37	2.39	5.65	1.54	51.78	9.90	-0.55	2.27	3.67	4.95
R_Pelvis_Lat_Tilt	0.40	1.65	4.06	2.22	20.56	11.14	-2.88	1.54	53.22	20.00
L_Pelvis_Lat_Tilt	0.40	1.65	4.06	2.22	20.56	11.14	-2.71	1.54	52.67	19.79
R_Pelvis_Fwd_Tilt	9.19	5.06	9.61	4.92	23.56	22.39	6.89	4.95	31.22	21.52
L_Pelvis_Fwd_Tilt	9.19	5.06	9.61	4.92	23.56	22.39	6.88	4.97	31.22	21.50
R_Pelvis_Rotation	9.64	4.44	9.96	4.61	3.22	3.35	-5.47	4.11	53.89	2.47
L_Pelvis_Rotation	9.64	4.44	9.96	4.61	3.22	3.35	-5.47	4.11	53.89	2.47
R_Foot_Orientation	-10.67	3.39	-7.58	3.76	17.33	2.40	-11.75	3.43	21.00	25.60
L_Foot_Orientation	-8.56	5.71	-5.89	5.47	19.33	13.01	-9.17	6.06	26.56	26.04

Table B.4 Swing Phase Kinematics of 5-year-old Male Subjects
(Max = Maximum, Sw. = Swing, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Maximum Swing		**Time of Max. Sw.**		**Minimum Swing**		**Time of Min. Sw.**		**Toe Off**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	3.05	9.07	66.98	8.45	-9.69	9.89	98.43	0.96	2.15	8.57
L_Hip_Rot_Ang	5.21	7.07	74.15	10.02	-6.79	9.99	98.82	0.83	3.44	8.79
R_Hip_Abd_Ang	-0.33	3.01	89.65	12.79	-5.91	2.67	71.09	10.04	-3.80	3.38
L_Hip_Abd_Ang	-0.48	2.23	95.82	6.36	-6.28	3.94	67.26	2.84	-4.63	4.26
R_Hip_Flex_Ang	34.59	5.60	93.20	3.97	-9.67	7.86	60.87	1.42	-9.67	7.86
L_Hip_Flex_Ang	33.69	5.63	93.60	3.75	-9.89	8.50	60.49	1.19	-9.89	8.50
R_Knee_Rot_Ang	29.14	8.60	74.76	2.09	5.80	10.99	89.98	17.16	14.67	5.61
L_Knee_Rot_Ang	36.13	12.62	74.04	1.85	5.98	11.54	89.71	16.61	18.91	9.24
R_Knee_Abd_Ang	3.94	7.11	78.43	10.99	-4.25	3.51	90.43	13.53	-0.26	4.19
L_Knee_Abd_Ang	4.92	5.38	76.49	9.65	-4.78	2.84	84.60	16.22	-0.51	3.94
R_Knee_Flex_Ang	70.53	4.81	74.87	1.08	9.77	6.66	98.87	0.27	36.27	5.72
L_Knee_Flex_Ang	68.90	3.27	74.49	0.58	7.10	5.30	99.04	0.35	33.97	5.88
R_Ank_Rot_Ang	-16.70	5.38	94.31	13.79	-43.98	6.81	77.87	0.64	-24.28	4.86
L_Ank_Rot_Ang	-13.91	8.86	94.38	13.20	-44.35	14.03	76.60	1.16	-23.49	9.63
R_Ank_Abd_Ang	1.07	2.97	68.31	11.43	-9.17	2.11	82.87	1.54	0.11	2.46
L_Ank_Abd_Ang	0.89	2.55	63.71	1.46	-8.05	2.98	82.04	1.33	0.17	1.90
R_Ank_Flex_Ang	11.29	2.22	89.43	2.87	-1.86	5.92	64.09	1.79	-0.48	5.87
L_Ank_Flex_Ang	10.62	2.69	89.93	4.30	-1.99	4.00	63.38	1.63	-0.96	4.10
R_Elbow_Ang	50.95	7.15	60.87	1.42	29.19	7.07	98.87	0.27	50.95	7.15
L_Elbow_Ang	49.96	9.72	60.49	1.19	30.39	5.09	99.04	0.35	49.96	9.72
R_Shl_Add_Ang	30.93	3.38	98.65	0.65	21.67	4.06	68.43	6.37	23.68	3.24
L_Shl_Add_Ang	29.82	4.70	94.26	13.19	22.68	4.41	71.49	6.74	25.19	5.12
R_Shl_Flex_Ang	-15.91	27.50	60.87	1.42	-68.36	9.13	98.87	0.27	-15.91	27.50
L_Shl_Flex_Ang	-10.90	20.36	60.49	1.19	-62.15	14.29	99.04	0.35	-10.90	20.36
R_Trunk_Lat_Tilt	1.95	1.47	63.76	3.43	-0.97	1.68	97.98	2.49	1.90	1.51
L_Trunk_Lat_Tilt	1.96	1.44	63.82	3.72	-0.97	1.68	98.15	2.58	1.89	1.47
R_Trunk_Fwd_Tilt	-0.51	1.70	92.65	2.92	-3.27	1.69	67.09	3.61	-2.88	1.75
L_Trunk_Fwd_Tilt	-0.51	1.70	92.82	2.76	-3.27	1.69	67.26	3.48	-2.80	1.65
R_Trunk_Rotation	5.18	1.99	61.43	1.97	-0.48	2.38	95.09	4.87	5.17	1.97
L_Trunk_Rotation	5.27	1.95	61.04	1.79	-0.48	2.38	95.26	4.79	5.25	1.94
R_Pelvis_Lat_Tilt	0.30	1.45	93.87	12.18	-3.87	1.62	68.43	3.58	-2.89	1.84
L_Pelvis_Lat_Tilt	0.30	1.45	94.04	12.32	-3.87	1.62	68.60	3.47	-2.72	1.80
R_Pelvis_Fwd_Tilt	9.07	4.85	94.31	3.12	6.80	5.17	68.31	2.37	7.26	5.16
L_Pelvis_Fwd_Tilt	9.07	4.85	94.49	3.08	6.80	5.17	68.49	2.18	7.35	5.12
R_Pelvis_Rotation	9.12	4.47	98.76	0.51	-4.71	3.94	60.87	1.42	-4.71	3.94
L_Pelvis_Rotation	9.12	4.47	98.93	0.44	-4.76	3.98	60.49	1.19	-4.76	3.98
R_Foot_Orientation	-9.73	3.41	74.20	17.62	-18.43	4.81	82.87	4.62	-10.79	3.69
L_Foot_Orientation	-7.69	6.17	62.49	3.45	-14.21	5.62	85.04	4.04	-7.88	6.23

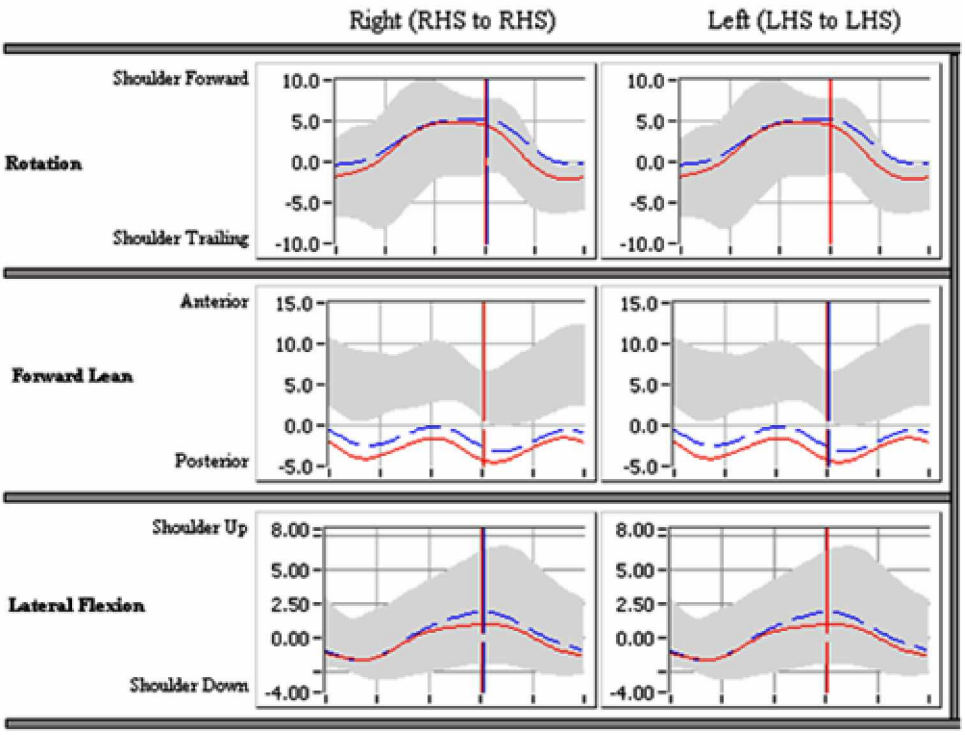

Figure B.1 Trunk Orientation Relative to Room (Degrees), 5-year-old subjects.

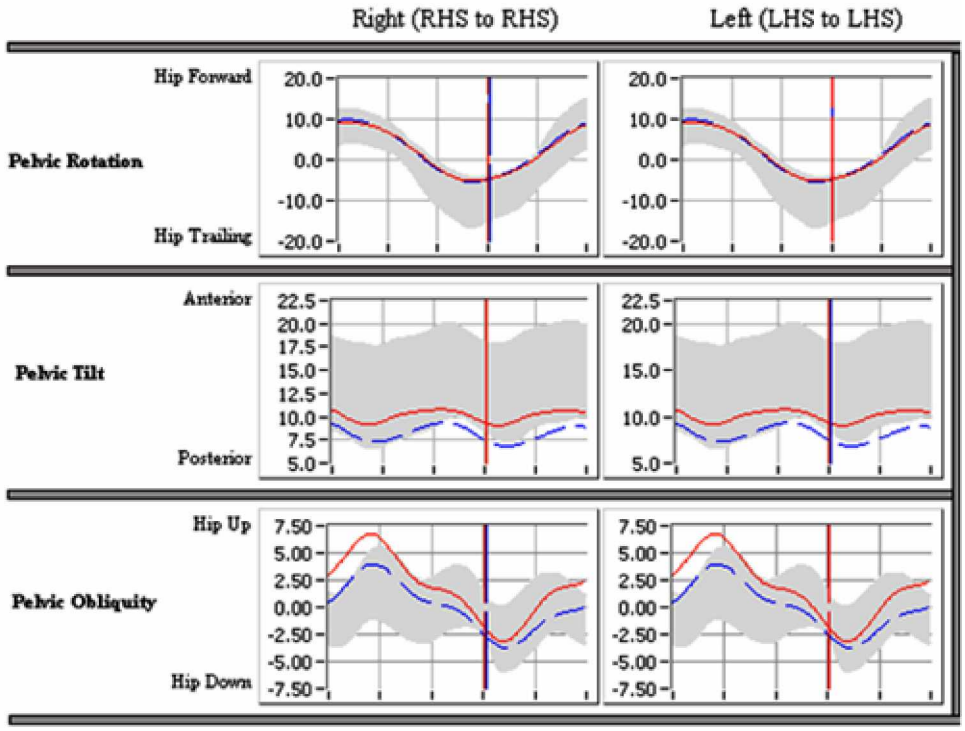

Figure B.2 Pelvis Orientation Relative to Room (Degrees), 5-year old subjects.

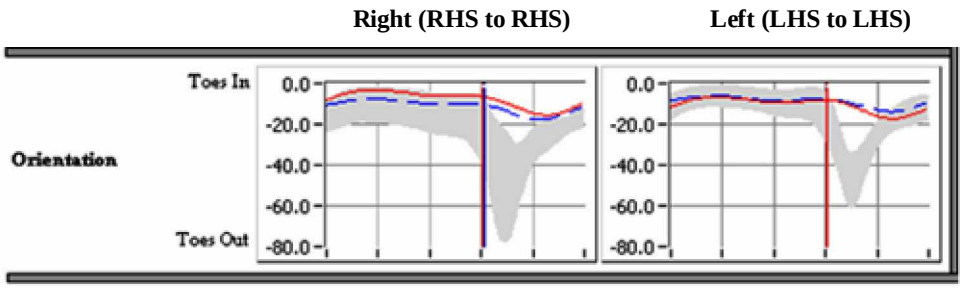

Figure B.3 Foot Orientation Relative to Room (Degrees), 5-year old subjects.

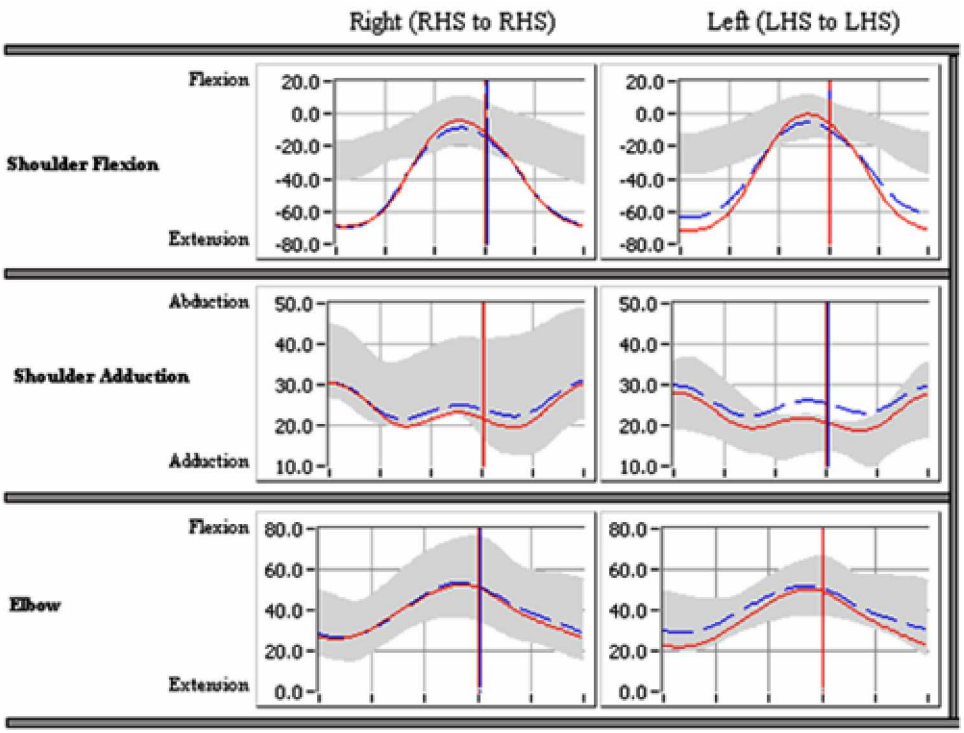

Figure B.4 Arm Joint Angles (Degrees), 5-year-old subjects.

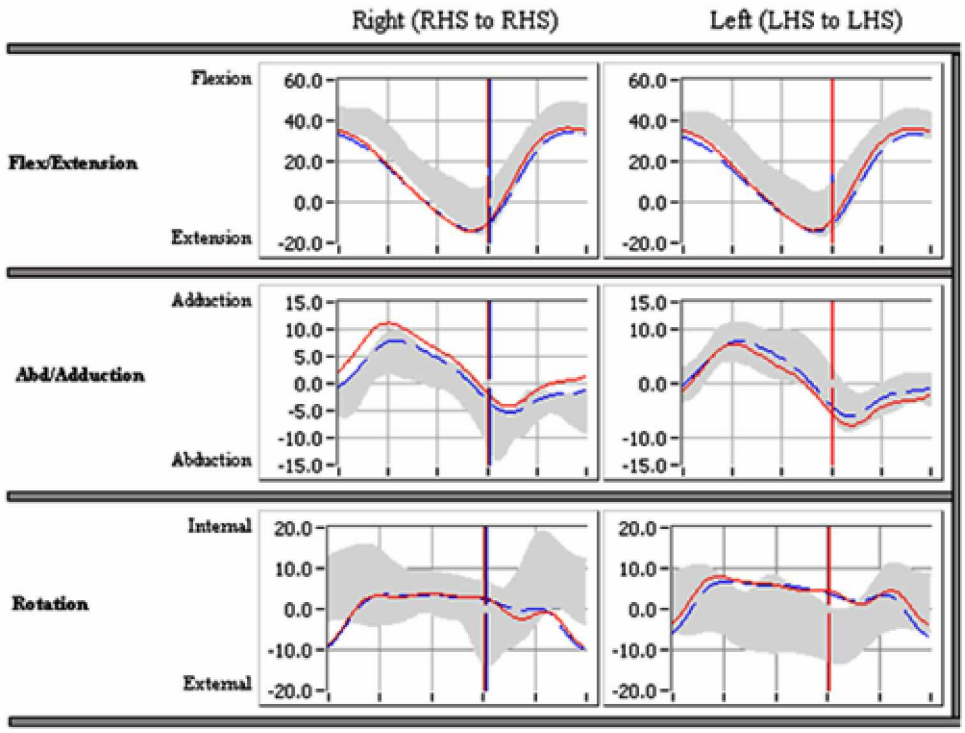

Figure B.5 Hip Joint Angles (Degrees), 5-year-old subjects.

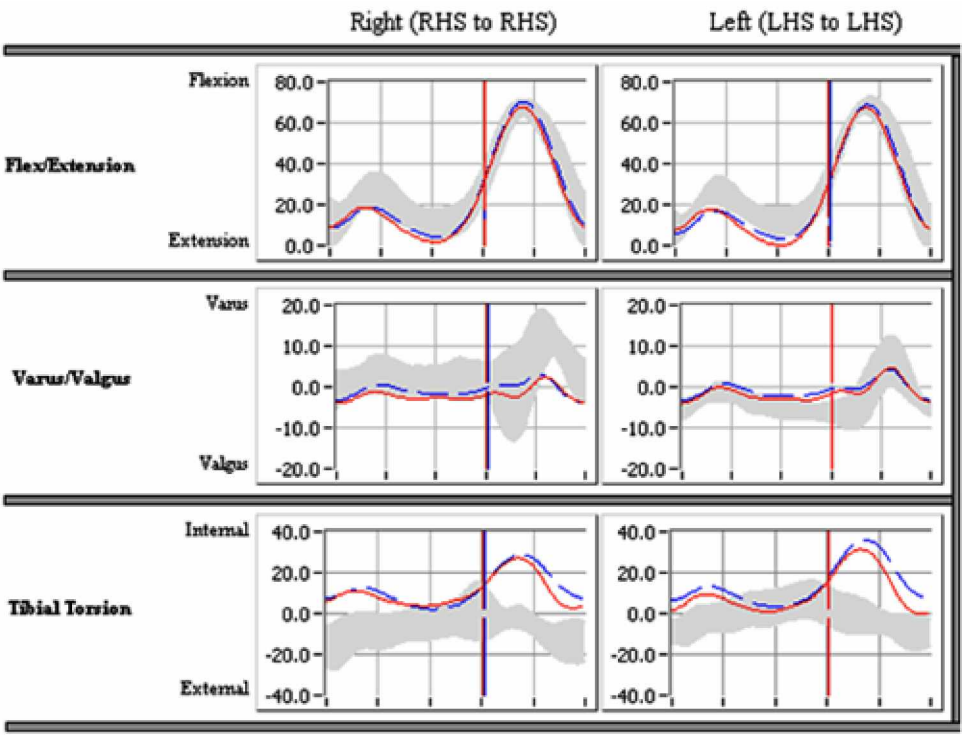

Figure B.6 Knee Joint Angles (Degrees), 5-year-old subjects.

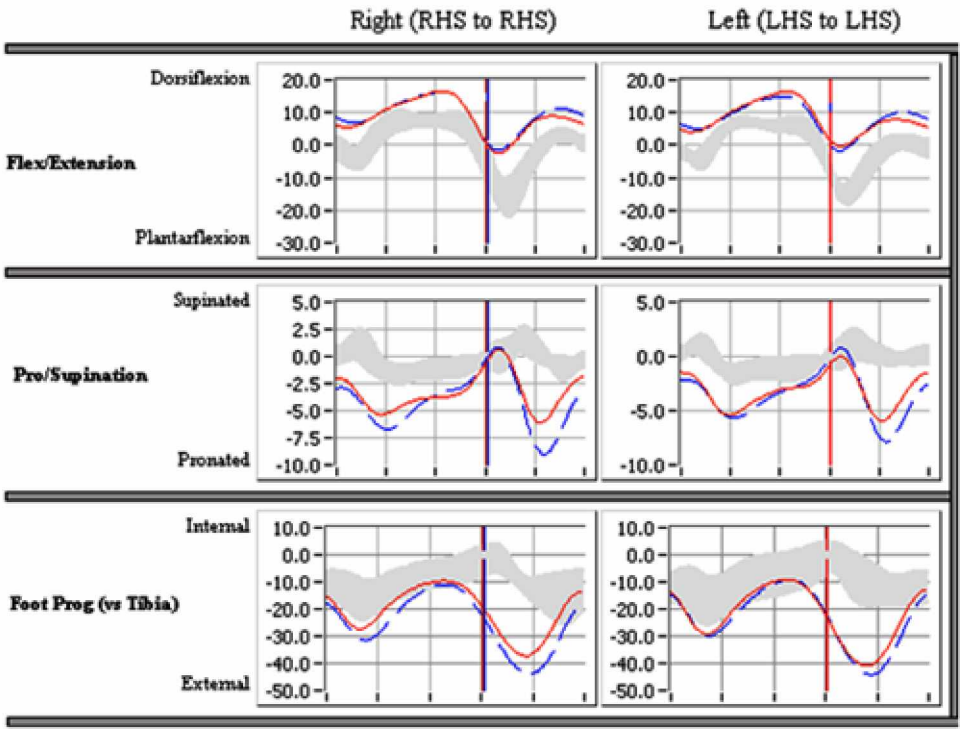

Figure B.7 Ankle Joint Angles (Degrees), 5-year-old subjects.

Seven-Year-Old Subjects

Table B.5 Stance Phase Kinematics of 7-year-old Female Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Foot Strike		**Maximum Stance**		**Time of Max. St.**		**Minimum Stance**		**Time of Min. St.**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-10.34	10.39	4.06	8.63	48.50	7.92	-10.34	10.39	0.00	0.00
L_Hip_Rot_Ang	-4.55	6.64	11.86	7.73	38.70	12.16	-4.55	6.64	0.00	0.00
R_Hip_Abd_Ang	1.20	2.62	9.05	2.73	18.50	1.58	-1.65	3.18	53.10	18.69
L_Hip_Abd_Ang	2.99	2.72	9.79	3.57	18.10	2.42	-1.74	1.96	53.00	18.66
R_Hip_Flex_Ang	39.07	6.36	39.07	6.36	0.00	0.00	-9.66	6.21	52.20	1.14
L_Hip_Flex_Ang	38.04	3.71	38.04	3.71	0.00	0.00	-10.14	5.44	51.20	0.92
R_Knee_Rot_Ang	5.76	11.21	15.45	17.33	35.20	23.17	-0.30	14.14	33.50	19.16
L_Knee_Rot_Ang	3.34	15.41	14.16	11.73	30.90	24.59	-4.68	14.23	38.90	15.08
R_Knee_Abd_Ang	-5.50	4.20	-0.56	4.14	52.90	8.94	-6.20	4.25	22.50	26.42
L_Knee_Abd_Ang	-5.46	2.32	0.04	3.63	45.20	20.74	-5.61	2.21	6.00	13.86
R_Knee_Flex_Ang	9.13	5.90	30.91	6.70	54.40	14.94	3.15	7.37	32.00	16.94
L_Knee_Flex_Ang	7.16	4.91	30.79	7.12	58.80	1.23	0.72	6.93	31.70	16.77
R_Ank_Rot_Ang	-11.72	12.61	-6.78	13.49	41.40	15.74	-27.61	16.77	22.60	19.21
L_Ank_Rot_Ang	-13.51	8.25	-7.32	8.09	39.20	14.10	-28.86	7.51	18.70	14.55
R_Ank_Abd_Ang	-1.28	1.38	0.23	1.32	49.20	17.94	-4.47	3.17	27.20	13.22
L_Ank_Abd_Ang	-0.70	0.53	0.12	1.19	41.20	26.96	-4.20	2.40	26.40	10.70
R_Ank_Flex_Ang	4.31	1.70	15.02	3.07	41.80	2.53	-0.97	4.44	53.70	16.80
L_Ank_Flex_Ang	1.84	2.49	14.56	2.26	42.70	2.00	-0.88	3.69	36.70	29.44
R_Elbow_Ang	26.74	9.60	40.77	8.07	51.00	4.29	25.08	9.55	8.50	2.51
L_Elbow_Ang	24.54	5.81	40.69	7.30	52.00	3.33	23.58	5.83	6.90	0.88
R_Shl_Add_Ang	23.63	4.65	24.28	4.50	11.90	20.42	18.36	4.55	41.00	16.78
L_Shl_Add_Ang	24.83	5.16	25.21	5.24	6.90	16.06	16.24	3.42	44.40	12.00
R_Shl_Flex_Ang	-56.89	13.07	-10.15	26.40	50.50	3.03	-57.19	13.39	2.40	2.50
L_Shl_Flex_Ang	-68.37	9.44	-7.72	23.26	49.80	4.18	-68.84	9.40	2.50	3.03
R_Trunk_Lat_Tilt	-0.21	1.59	1.79	1.59	42.70	21.58	-0.79	1.46	16.00	20.16
L_Trunk_Lat_Tilt	-0.21	1.59	1.78	1.57	42.50	21.43	-0.79	1.46	16.00	20.16
R_Trunk_Fwd_Tilt	1.21	3.89	1.53	3.62	27.10	18.88	-1.59	4.01	49.90	18.95
L_Trunk_Fwd_Tilt	1.21	3.89	1.53	3.62	27.10	18.88	-1.60	4.04	49.80	18.91
R_Trunk_Rotation	-2.68	3.30	3.09	2.64	42.70	9.09	-3.09	3.48	6.60	3.95
L_Trunk_Rotation	-2.68	3.30	3.07	2.67	42.50	8.68	-3.09	3.48	6.60	3.95
R_Pelvis_Lat_Tilt	1.10	1.64	4.36	1.63	14.60	1.17	-3.27	2.53	59.00	1.15
L_Pelvis_Lat_Tilt	1.10	1.64	4.36	1.63	14.60	1.17	-3.18	2.37	58.80	1.23
R_Pelvis_Fwd_Tilt	12.96	3.41	13.78	3.32	32.90	10.92	11.52	3.15	39.20	23.74
L_Pelvis_Fwd_Tilt	12.96	3.41	13.78	3.32	32.90	10.92	11.50	3.13	39.30	23.83
R_Pelvis_Rotation	8.17	2.86	8.49	2.66	3.50	4.90	-4.92	2.14	54.10	3.14
L_Pelvis_Rotation	8.17	2.86	8.49	2.66	3.50	4.90	-4.91	2.14	54.00	3.06
R_Foot_Orientation	-7.94	2.62	-3.74	4.55	23.20	13.62	-9.10	3.20	39.00	27.30
L_Foot_Orientation	-10.01	3.93	-4.36	5.19	26.70	16.71	-11.28	4.30	28.30	29.97

Table B.6 Swing Phase Kinematics of 7-year-old Female Subjects
(Max = Maximum, Sw. = Swing, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Maximum Swing		**Time of Max. Sw.**		**Minimum Swing**		**Time of Min. Sw.**		**Toe Off**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	2.83	8.69	60.53	2.51	-10.62	10.35	98.13	1.28	2.73	8.84
L_Hip_Rot_Ang	9.25	8.42	64.13	9.49	-5.45	7.06	97.83	1.25	8.60	7.71
R_Hip_Abd_Ang	0.52	2.96	90.53	12.97	-4.06	3.24	67.23	1.82	-2.12	3.21
L_Hip_Abd_Ang	2.23	2.70	95.93	6.16	-3.87	1.91	66.43	1.93	-2.18	1.95
R_Hip_Flex_Ang	38.95	6.23	92.23	3.59	-4.49	5.74	60.03	1.21	-4.49	5.74
L_Hip_Flex_Ang	37.80	3.68	92.13	3.56	-4.05	5.45	59.73	1.20	-4.05	5.45
R_Knee_Rot_Ang	25.68	16.64	73.53	3.44	1.23	11.69	84.33	17.10	11.10	18.75
L_Knee_Rot_Ang	28.01	14.47	72.93	3.55	-0.17	15.09	88.23	15.07	11.80	13.22
R_Knee_Abd_Ang	0.99	6.33	73.63	12.11	-6.56	4.33	90.03	14.56	-1.55	5.48
L_Knee_Abd_Ang	4.12	6.68	74.23	8.19	-5.83	1.82	92.53	12.13	0.20	4.19
R_Knee_Flex_Ang	65.41	4.42	73.73	1.54	8.31	5.71	99.03	0.21	33.84	6.94
L_Knee_Flex_Ang	64.49	3.08	72.83	1.86	5.96	4.02	98.73	0.56	34.06	6.93
R_Ank_Rot_Ang	-9.72	12.20	90.03	16.13	-38.83	16.88	75.73	2.89	-19.69	19.62
L_Ank_Rot_Ang	-11.36	8.08	97.93	1.26	-41.67	10.36	75.43	2.76	-23.07	7.95
R_Ank_Abd_Ang	1.03	1.65	68.43	11.12	-5.01	2.45	82.13	1.07	-0.02	1.24
L_Ank_Abd_Ang	1.42	2.04	68.33	10.95	-4.77	2.33	81.13	1.95	0.12	1.81
R_Ank_Flex_Ang	8.12	1.62	87.53	2.37	-3.28	4.50	63.93	1.38	-1.79	4.66
L_Ank_Flex_Ang	6.43	2.39	85.63	2.21	-3.04	4.21	63.73	1.05	-1.20	4.05
R_Elbow_Ang	38.88	7.46	60.03	1.21	26.53	10.27	99.03	0.21	38.88	7.46
L_Elbow_Ang	38.48	7.03	59.73	1.20	25.11	7.42	96.13	8.79	38.48	7.03
R_Shl_Add_Ang	23.52	4.34	91.13	16.19	17.73	3.96	69.63	7.70	19.33	4.81
L_Shl_Add_Ang	24.12	4.05	95.03	12.04	16.40	3.60	68.23	7.87	18.01	4.69
R_Shl_Flex_Ang	-15.84	26.60	60.03	1.21	-57.46	13.47	99.03	0.21	-15.84	26.60
L_Shl_Flex_Ang	-15.80	26.99	59.73	1.20	-68.87	9.60	97.63	4.06	-15.80	26.99
R_Trunk_Lat_Tilt	1.73	1.51	69.43	15.91	-0.23	1.40	90.53	15.58	1.36	1.64
L_Trunk_Lat_Tilt	1.72	1.50	69.53	15.98	-0.24	1.39	90.23	15.84	1.33	1.62
R_Trunk_Fwd_Tilt	0.59	4.01	90.53	1.84	-1.94	3.97	64.73	2.90	-1.62	4.08
L_Trunk_Fwd_Tilt	0.59	4.01	90.43	1.97	-1.94	3.97	64.53	3.10	-1.62	4.11
R_Trunk_Rotation	2.36	2.78	60.63	1.56	-2.52	3.01	90.63	6.92	2.35	2.78
L_Trunk_Rotation	2.36	2.77	60.43	1.72	-2.52	3.01	90.53	7.07	2.33	2.79
R_Pelvis_Lat_Tilt	0.58	1.89	96.53	5.33	-4.27	2.57	65.63	1.57	-3.52	2.57
L_Pelvis_Lat_Tilt	0.58	1.89	96.43	5.33	-4.27	2.57	65.53	1.55	-3.43	2.41
R_Pelvis_Fwd_Tilt	12.67	2.96	83.43	14.24	11.08	3.10	78.03	16.17	11.75	3.04
L_Pelvis_Fwd_Tilt	12.68	2.95	83.33	14.09	11.08	3.10	77.83	16.31	11.75	3.03
R_Pelvis_Rotation	8.41	3.03	99.03	0.21	-4.18	1.70	61.13	2.10	-4.13	1.72
L_Pelvis_Rotation	8.41	3.03	98.93	0.32	-4.29	1.77	60.93	2.04	-4.22	1.79
R_Foot_Orientation	-6.77	4.96	80.03	20.12	-17.38	3.48	80.03	3.22	-7.71	5.44
L_Foot_Orientation	-7.08	6.28	79.53	20.65	-18.79	3.87	81.73	3.30	-8.19	6.83

Table B.7 Stance Phase Kinematics of 7-year-old Male Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Foot Strike		**Maximum Stance**		**Time of Max. St.**		**Minimum Stance**		**Time of Min. St.**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-15.33	4.95	0.42	5.61	51.20	14.20	-15.33	4.95	0.00	0.00
L_Hip_Rot_Ang	-7.43	7.40	6.12	8.25	37.80	20.20	-7.43	7.40	0.00	0.00
R_Hip_Abd_Ang	2.52	4.39	9.90	3.68	20.40	4.86	-0.53	3.33	53.60	18.87
L_Hip_Abd_Ang	-1.65	3.05	5.93	2.16	22.60	8.47	-4.26	2.62	53.80	18.94
R_Hip_Flex_Ang	33.29	9.42	33.33	9.43	0.40	1.26	-13.25	6.39	53.30	0.67
L_Hip_Flex_Ang	31.61	9.79	31.64	9.79	0.30	0.95	-14.84	6.35	53.50	0.85
R_Knee_Rot_Ang	6.95	12.93	14.99	11.22	16.90	15.29	0.50	11.64	31.00	17.11
L_Knee_Rot_Ang	0.94	18.22	13.43	15.62	40.80	24.82	-4.34	15.88	27.40	19.22
R_Knee_Abd_Ang	-5.05	3.26	-1.98	2.34	41.60	16.55	-5.92	3.21	23.60	28.69
L_Knee_Abd_Ang	-4.08	2.82	1.29	4.26	47.80	17.20	-4.39	3.15	21.00	26.70
R_Knee_Flex_Ang	6.62	5.58	29.62	5.40	59.60	1.17	2.60	3.80	33.10	17.50
L_Knee_Flex_Ang	2.94	6.10	26.66	5.30	59.80	1.14	-1.31	3.80	32.40	17.23
R_Ank_Rot_Ang	-10.18	10.19	-4.50	10.93	31.60	22.09	-26.30	8.17	12.90	0.74
L_Ank_Rot_Ang	-9.61	10.41	-4.98	7.66	33.60	18.02	-26.28	10.00	13.70	1.25
R_Ank_Abd_Ang	-1.17	1.02	0.50	0.83	43.50	23.81	-4.25	2.14	24.40	12.02
L_Ank_Abd_Ang	-1.04	1.37	0.48	1.65	45.60	22.25	-3.63	1.97	25.50	13.50
R_Ank_Flex_Ang	4.86	2.44	15.00	2.85	43.20	2.30	-0.43	2.94	59.60	1.17
L_Ank_Flex_Ang	3.67	3.08	13.78	2.55	43.90	3.07	-1.24	4.06	54.80	16.13
R_Elbow_Ang	25.53	8.25	44.00	10.08	52.90	3.81	23.84	8.19	7.70	1.42
L_Elbow_Ang	20.66	5.78	41.88	7.23	55.30	2.36	19.30	5.41	6.90	1.66
R_Shl_Add_Ang	26.33	5.35	26.98	5.41	10.70	22.04	18.40	2.62	33.20	10.69
L_Shl_Add_Ang	24.45	4.12	25.46	3.75	17.90	24.78	17.22	2.33	29.10	12.22
R_Shl_Flex_Ang	-59.48	13.41	-6.19	21.96	51.00	2.36	-60.44	12.70	5.10	2.47
L_Shl_Flex_Ang	-57.85	15.30	2.77	19.71	52.30	3.27	-58.92	14.92	5.30	3.62
R_Trunk_Lat_Tilt	-0.79	1.95	1.01	1.81	59.30	1.42	-1.79	1.96	14.90	6.94
L_Trunk_Lat_Tilt	-0.79	1.95	1.06	1.82	59.70	1.34	-1.79	1.96	14.90	6.94
R_Trunk_Fwd_Tilt	-0.45	2.41	0.03	2.54	32.90	17.45	-2.94	2.53	38.10	22.68
L_Trunk_Fwd_Tilt	-0.45	2.41	0.03	2.54	32.90	17.45	-2.97	2.58	38.00	23.25
R_Trunk_Rotation	-2.73	4.34	2.77	5.27	47.20	11.62	-3.11	4.61	6.60	7.01
L_Trunk_Rotation	-2.73	4.34	2.78	5.27	47.30	11.74	-3.11	4.61	6.60	7.01
R_Pelvis_Lat_Tilt	2.15	1.89	5.04	2.05	16.20	2.10	-0.91	2.01	59.60	1.17
L_Pelvis_Lat_Tilt	2.15	1.89	5.04	2.05	16.20	2.10	-0.97	2.03	59.80	1.14
R_Pelvis_Fwd_Tilt	9.27	6.28	9.88	6.62	26.10	22.77	7.85	6.36	28.70	21.34
L_Pelvis_Fwd_Tilt	9.27	6.28	9.88	6.62	26.10	22.77	7.82	6.35	29.30	21.11
R_Pelvis_Rotation	6.78	5.68	7.52	4.49	4.80	9.16	-6.67	1.93	53.20	3.58
L_Pelvis_Rotation	6.78	5.68	7.52	4.49	4.80	9.16	-6.67	1.93	53.20	3.58
R_Foot_Orientation	-10.86	6.58	-7.08	6.65	16.60	15.81	-12.46	7.46	39.80	27.76
L_Foot_Orientation	-10.89	7.88	-5.83	7.92	20.50	13.13	-11.45	8.21	19.90	26.22

Table B.8 Swing Phase Kinematics of 7-year-old Male Subjects
(Max = Maximum, Sw. = Swing, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Maximum Swing		**Time of Max. Sw.**		**Minimum Swing**		**Time of Min. Sw.**		**Toe Off**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	0.01	5.98	63.10	7.54	-15.94	4.72	98.10	1.09	-0.16	6.06
L_Hip_Rot_Ang	5.12	8.51	66.62	9.31	-8.39	7.68	98.52	0.79	4.70	8.52
R_Hip_Abd_Ang	2.64	3.89	90.80	12.45	-2.32	3.41	70.10	9.69	-0.63	3.08
L_Hip_Abd_Ang	-2.16	3.35	87.62	18.56	-6.74	2.73	69.32	2.63	-4.40	3.13
R_Hip_Flex_Ang	34.39	9.36	93.40	3.41	-8.53	6.56	60.50	1.12	-8.53	6.56
L_Hip_Flex_Ang	31.98	9.37	94.02	3.10	-10.22	6.49	60.92	1.05	-10.22	6.49
R_Knee_Rot_Ang	24.45	9.52	75.00	2.73	2.19	13.11	88.90	15.06	10.17	11.96
L_Knee_Rot_Ang	30.40	13.27	74.42	3.08	-1.43	18.61	93.42	11.55	10.89	17.16
R_Knee_Abd_Ang	-0.75	3.65	75.80	10.58	-7.09	4.26	84.70	12.73	-3.43	3.52
L_Knee_Abd_Ang	5.94	6.34	81.32	9.07	-4.87	3.73	93.82	11.33	0.79	5.68
R_Knee_Flex_Ang	65.08	4.59	74.30	1.14	6.08	5.46	98.90	0.29	32.88	5.49
L_Knee_Flex_Ang	63.38	6.11	74.62	0.92	2.69	5.31	99.12	0.30	30.01	5.45
R_Ank_Rot_Ang	-7.99	11.19	98.30	1.10	-36.63	7.50	76.50	2.00	-18.69	8.67
L_Ank_Rot_Ang	-8.25	9.94	98.92	0.60	-38.95	8.38	76.32	2.54	-20.40	9.42
R_Ank_Abd_Ang	1.69	1.21	68.50	10.60	-5.41	1.55	81.20	1.97	0.38	1.10
L_Ank_Abd_Ang	1.56	2.01	67.82	10.41	-5.91	2.10	81.02	0.96	0.49	1.62
R_Ank_Flex_Ang	8.53	1.69	87.50	4.09	-3.59	3.57	64.30	1.39	-1.54	3.03
L_Ank_Flex_Ang	8.60	2.39	85.62	3.70	-3.78	4.13	64.02	1.23	-2.23	4.08
R_Elbow_Ang	41.90	9.30	60.50	1.12	26.55	8.67	98.90	0.29	41.90	9.30
L_Elbow_Ang	40.72	7.38	60.92	1.05	21.43	6.56	99.12	0.30	40.72	7.38
R_Shl_Add_Ang	26.23	4.47	90.90	15.89	19.64	3.36	71.50	7.57	21.96	3.85
L_Shl_Add_Ang	24.63	3.26	90.62	16.10	17.90	3.05	73.92	8.22	20.68	3.95
R_Shl_Flex_Ang	-12.36	22.90	60.50	1.12	-57.94	11.47	98.90	0.29	-12.36	22.90
L_Shl_Flex_Ang	-2.66	20.92	60.92	1.05	-55.86	14.75	98.92	0.82	-2.66	20.92
R_Trunk_Lat_Tilt	1.38	1.82	65.70	4.64	-0.60	1.93	96.50	5.21	1.06	1.79
L_Trunk_Lat_Tilt	1.38	1.83	65.72	4.77	-0.60	1.93	96.72	5.43	1.11	1.81
R_Trunk_Fwd_Tilt	-0.07	2.26	92.60	2.60	-3.06	2.55	64.40	2.52	-2.88	2.57
L_Trunk_Fwd_Tilt	-0.07	2.26	92.82	2.47	-3.06	2.55	64.62	2.48	-2.90	2.59
R_Trunk_Rotation	2.09	5.41	61.00	1.10	-3.57	4.82	93.80	5.71	2.06	5.41
L_Trunk_Rotation	2.06	5.39	61.62	1.07	-3.57	4.82	94.02	5.80	2.03	5.40
R_Pelvis_Lat_Tilt	1.92	1.84	94.30	6.00	-1.93	1.82	66.60	1.89	-1.15	1.98
L_Pelvis_Lat_Tilt	1.92	1.84	94.52	5.88	-1.93	1.82	66.82	1.79	-1.20	1.99
R_Pelvis_Fwd_Tilt	9.43	6.32	88.20	12.61	7.72	6.42	73.70	14.27	8.15	6.30
L_Pelvis_Fwd_Tilt	9.43	6.32	88.42	12.90	7.72	6.42	73.92	14.25	8.12	6.29
R_Pelvis_Rotation	6.22	5.40	95.10	12.07	-6.00	2.73	62.40	6.20	-5.61	2.08
L_Pelvis_Rotation	6.22	5.40	95.32	12.01	-5.94	2.73	62.82	6.17	-5.55	2.06
R_Foot_Orientation	-10.52	7.53	76.60	19.32	-19.91	7.99	80.70	7.15	-11.96	8.44
L_Foot_Orientation	-8.22	8.95	63.72	3.64	-17.08	8.92	86.22	2.68	-8.52	9.22

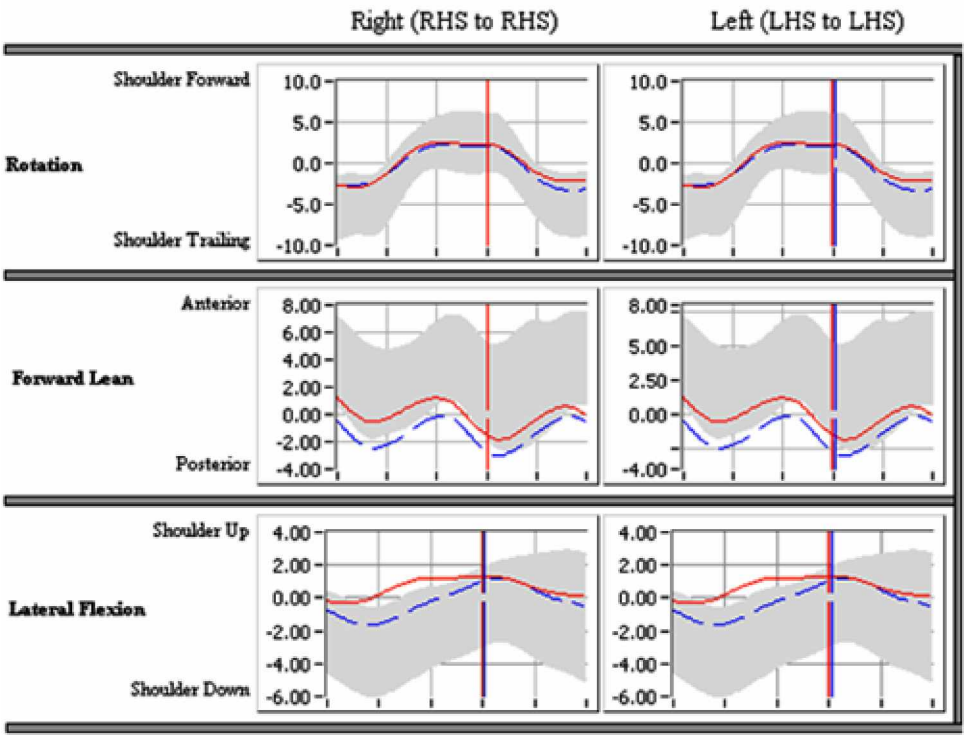

Figure B.8 Trunk Orientation Relative to Room (Degrees), 7-year-old subjects.

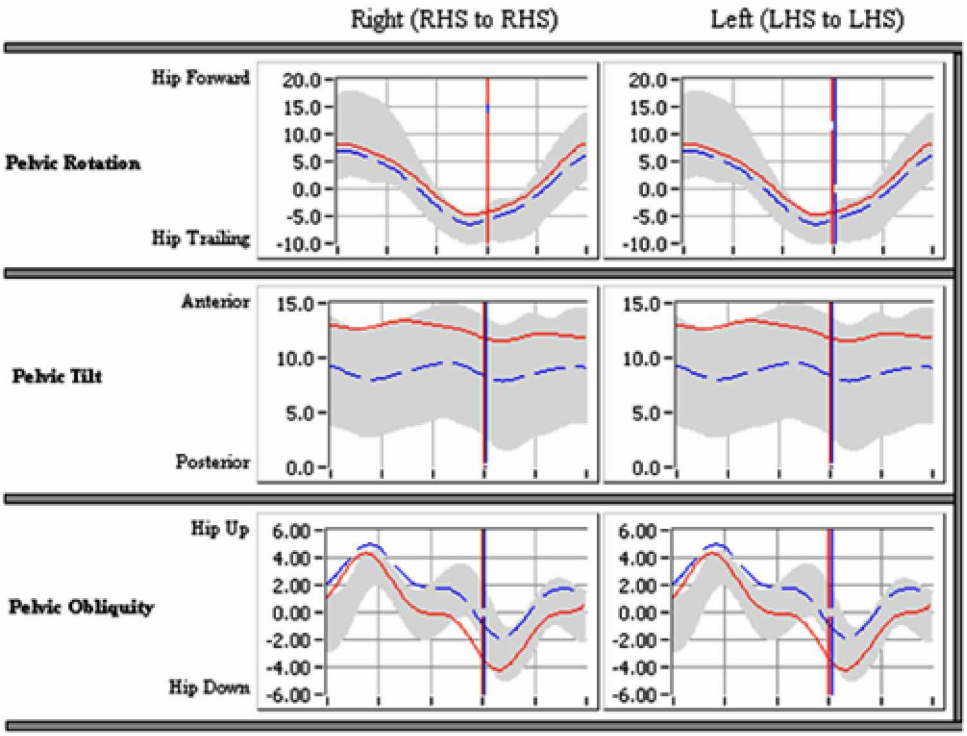

Figure B.9 Pelvis Orientation Relative to Room (Degrees), 7-year-old subjects.

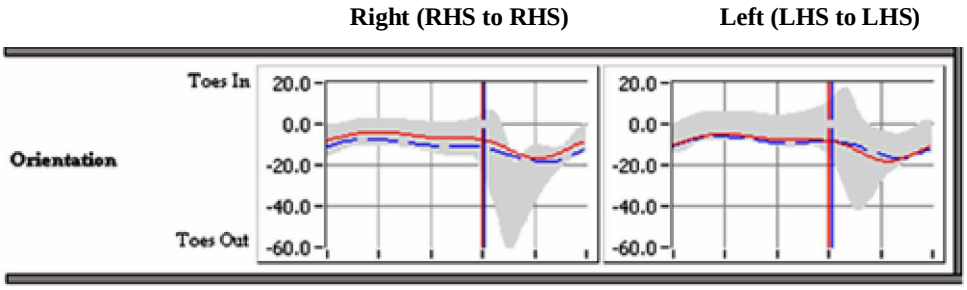

Figure B.10 Foot Orientation Relative to Room (Degrees), 7-year-old subjects.

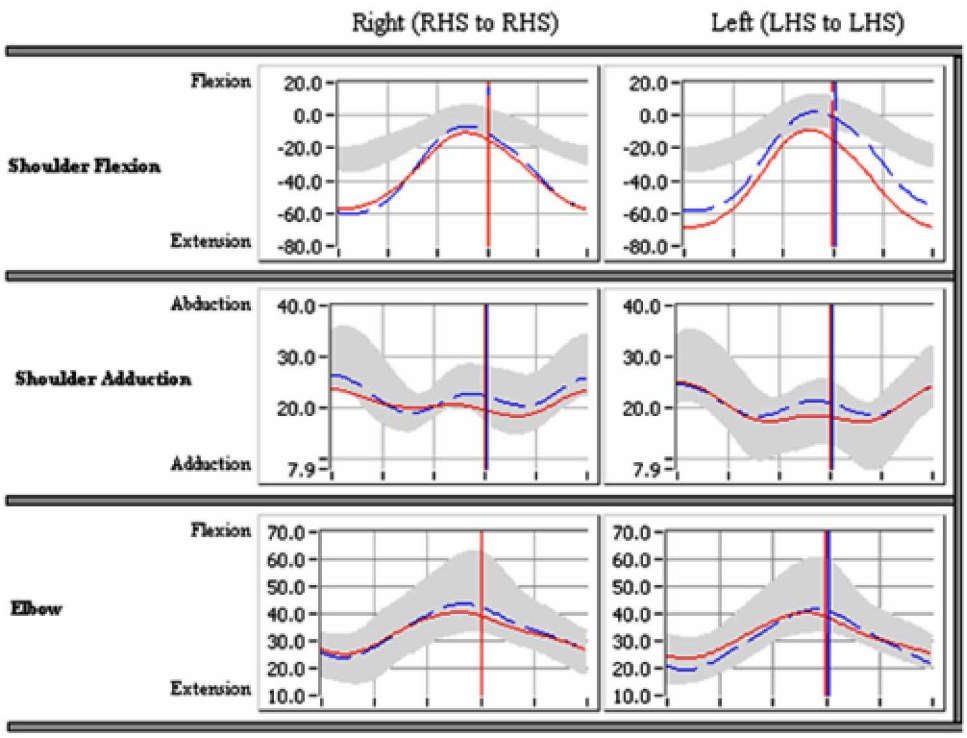

Figure B.11 Arm Joint Angles (Degrees), 7-year-old subjects.

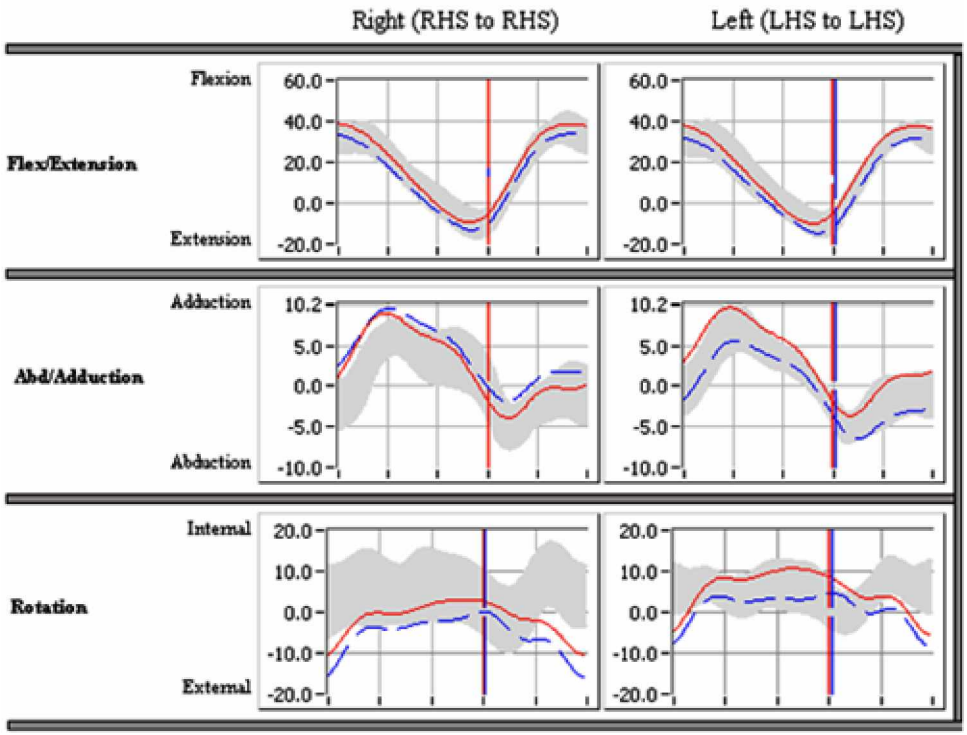

Figure B.12 Hip Joint Angles (Degrees), 7-year-old subjects.

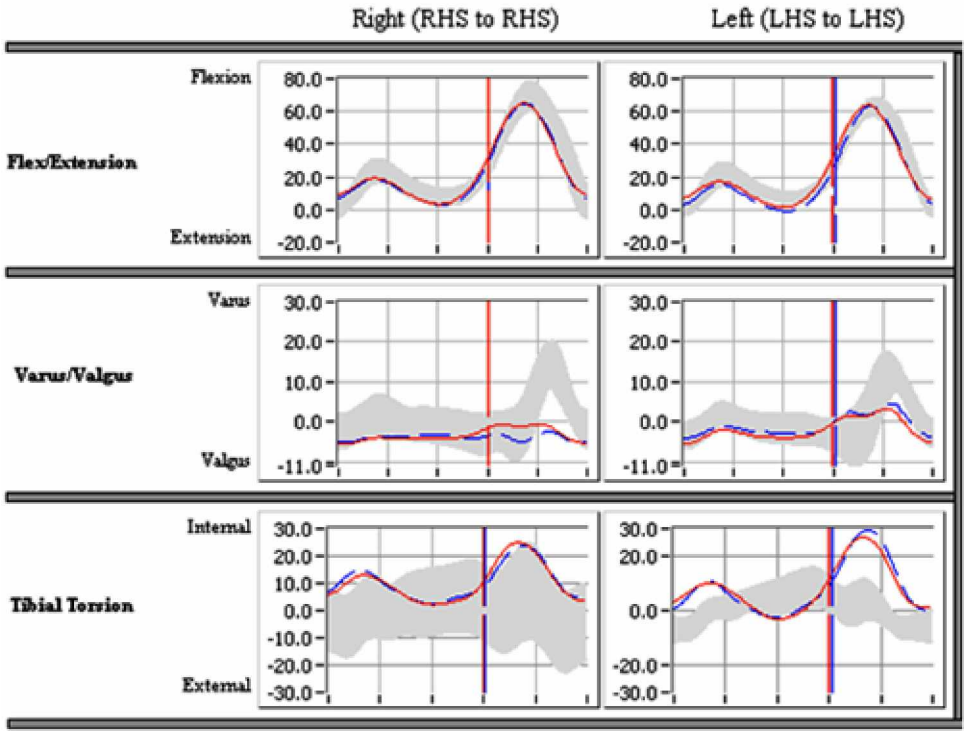

Figure B.13 Knee Joint Angles (Degrees), 7-year-old subjects.

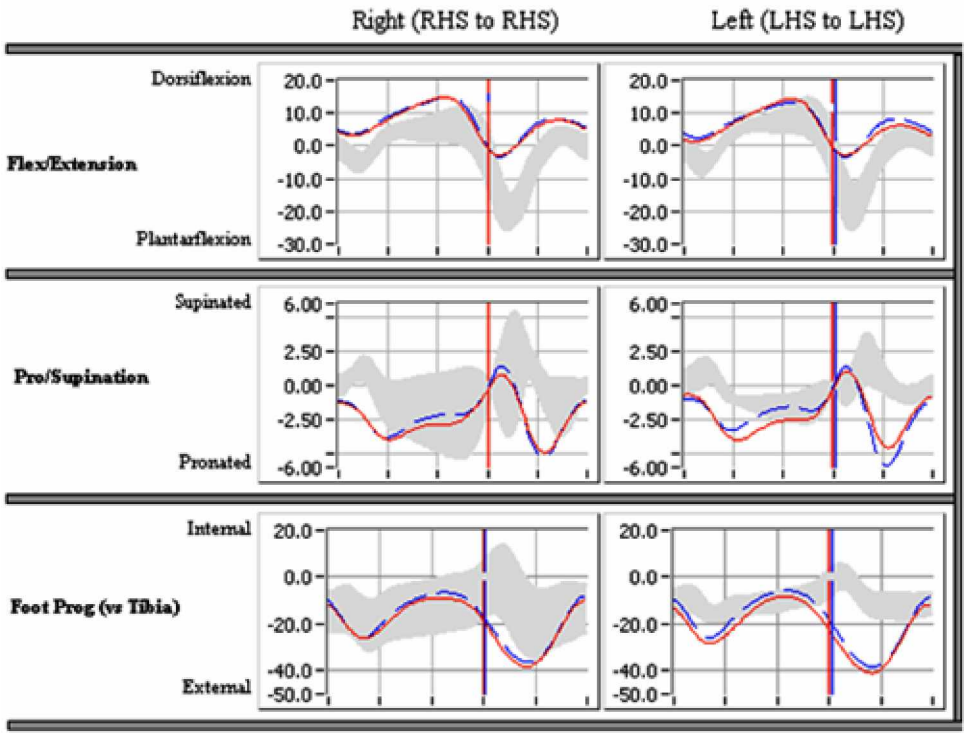

Figure B.14 Ankle Joint Angles (Degrees), 7-year-old subjects.

Eight-Year-Old Subjects

Table B.9 Stance Phase Kinematics of 8-year-old Female Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Foot Strike		**Maximum Stance**		**Time of Max. St.**		**Minimum Stance**		**Time of Min. St.**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-5.42	7.73	9.22	8.28	30.90	19.88	-5.42	7.73	0.00	0.00
L_Hip_Rot_Ang	-8.86	12.16	5.20	10.43	22.70	10.68	-8.89	12.18	5.80	18.34
R_Hip_Abd_Ang	2.98	3.77	10.42	3.32	17.30	1.42	-3.40	3.59	60.20	0.92
L_Hip_Abd_Ang	0.76	2.30	8.40	3.08	18.80	2.04	-4.62	3.72	59.70	1.16
R_Hip_Flex_Ang	35.84	3.87	35.99	3.88	1.20	1.99	-11.31	5.89	53.90	1.29
L_Hip_Flex_Ang	36.15	5.04	36.25	5.12	1.00	1.76	-12.20	4.80	53.20	1.48
R_Knee_Rot_Ang	2.87	11.77	16.50	14.80	30.90	23.73	-2.10	12.80	22.10	19.91
L_Knee_Rot_Ang	2.61	16.78	18.32	18.35	46.20	21.84	-1.42	15.55	15.00	19.22
R_Knee_Abd_Ang	-4.75	3.08	-1.07	4.90	40.80	21.39	-5.07	3.44	9.00	17.53
L_Knee_Abd_Ang	-3.81	2.07	1.14	3.02	37.10	19.54	-5.02	2.54	24.00	29.36
R_Knee_Flex_Ang	7.89	2.96	30.62	5.95	51.00	19.26	3.12	4.01	35.50	13.35
L_Knee_Flex_Ang	6.85	5.82	30.85	6.04	50.50	19.53	2.62	3.31	27.30	19.22
R_Ank_Rot_Ang	-12.77	6.92	-10.01	6.88	28.10	24.47	-33.43	13.93	14.20	1.69
L_Ank_Rot_Ang	-12.27	8.88	-10.37	9.06	20.90	22.44	-33.00	11.76	14.50	1.90
R_Ank_Abd_Ang	-0.65	0.85	0.92	0.87	60.20	0.92	-5.82	3.49	27.30	11.58
L_Ank_Abd_Ang	-0.46	0.71	0.95	0.96	48.60	22.76	-5.70	3.44	33.80	14.01
R_Ank_Flex_Ang	2.15	3.06	14.41	2.66	42.00	6.63	-3.22	3.03	49.30	23.36
L_Ank_Flex_Ang	1.34	3.17	14.37	2.58	44.00	2.26	-3.03	2.57	42.70	26.97
R_Elbow_Ang	25.54	6.70	37.14	9.67	52.80	2.90	23.49	6.31	10.10	2.88
L_Elbow_Ang	24.98	4.67	39.96	9.29	51.00	4.94	23.32	4.17	8.80	1.99
R_Shl_Add_Ang	22.46	5.28	23.32	5.36	20.70	23.57	16.66	3.60	41.10	15.54
L_Shl_Add_Ang	21.99	4.27	22.23	4.27	6.90	14.90	14.95	3.71	36.30	14.28
R_Shl_Flex_Ang	-59.04	14.01	-8.13	19.62	50.70	2.83	-59.76	14.04	3.70	3.06
L_Shl_Flex_Ang	-65.17	11.72	-1.53	12.76	50.80	2.20	-65.79	12.12	3.60	3.50
R_Trunk_Lat_Tilt	-0.70	2.70	1.04	2.29	44.30	18.45	-1.01	2.70	10.30	14.14
L_Trunk_Lat_Tilt	-0.70	2.70	1.03	2.31	44.10	18.25	-1.01	2.70	10.30	14.14
R_Trunk_Fwd_Tilt	0.20	2.29	1.22	2.21	38.40	13.63	-2.10	2.66	32.70	23.97
L_Trunk_Fwd_Tilt	0.20	2.29	1.22	2.21	38.40	13.63	-2.04	2.62	27.70	21.42
R_Trunk_Rotation	-0.11	3.01	5.93	3.61	46.00	9.56	-0.46	3.21	3.90	5.38
L_Trunk_Rotation	-0.11	3.01	5.91	3.63	45.90	9.39	-0.46	3.21	3.90	5.38
R_Pelvis_Lat_Tilt	1.92	2.52	5.70	2.84	15.00	1.05	-4.30	2.73	60.20	0.92
L_Pelvis_Lat_Tilt	1.92	2.52	5.70	2.84	15.00	1.05	-4.15	2.75	59.70	1.16
R_Pelvis_Fwd_Tilt	11.13	2.57	12.41	2.28	19.50	17.88	10.07	2.64	32.60	25.77
L_Pelvis_Fwd_Tilt	11.13	2.57	12.41	2.28	19.50	17.88	10.11	2.62	32.40	25.54
R_Pelvis_Rotation	5.99	3.31	6.96	3.14	9.60	7.99	-5.16	2.26	56.30	4.06
L_Pelvis_Rotation	5.99	3.31	6.96	3.14	9.60	7.99	-5.12	2.31	55.70	3.33
R_Foot_Orientation	-8.66	3.96	-4.29	2.93	16.60	5.93	-10.23	3.28	29.10	30.74
L_Foot_Orientation	-13.54	6.15	-8.65	5.62	30.70	20.11	-14.48	5.67	14.30	23.77

Table B.10 Swing Phase Kinematics of 8-year-old Female Subjects
(Max = Maximum, Sw. = Swing, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Maximum Swing		**Time of Max. Sw.**		**Minimum Swing**		**Time of Min. Sw.**		**Toe Off**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	7.04	7.20	67.51	10.41	-6.09	7.49	98.21	0.92	5.58	8.15
L_Hip_Rot_Ang	2.24	10.72	71.70	10.48	-9.69	12.04	94.70	12.34	-0.19	10.59
R_Hip_Abd_Ang	3.04	3.57	93.71	6.84	-5.00	3.55	65.91	1.83	-3.86	3.60
L_Hip_Abd_Ang	0.11	2.51	92.50	7.08	-6.55	3.57	66.10	2.51	-5.12	3.72
R_Hip_Flex_Ang	35.51	4.06	93.41	4.19	-6.39	5.39	61.21	0.91	-6.39	5.39
L_Hip_Flex_Ang	35.63	4.98	93.60	4.23	-7.09	4.40	60.80	1.22	-7.09	4.40
R_Knee_Rot_Ang	27.12	13.33	73.91	2.71	-1.98	10.33	92.21	11.60	11.89	11.42
L_Knee_Rot_Ang	31.35	17.80	72.90	3.59	-1.98	16.35	95.60	4.06	16.83	16.29
R_Knee_Abd_Ang	2.11	5.90	74.71	10.57	-6.13	4.78	87.61	14.45	-1.32	5.33
L_Knee_Abd_Ang	4.19	7.91	87.30	8.74	-9.80	7.52	83.10	13.98	-2.39	5.10
R_Knee_Flex_Ang	64.58	7.68	74.81	0.98	6.74	2.72	99.01	0.29	32.92	6.43
L_Knee_Flex_Ang	63.93	7.61	74.10	1.22	5.40	4.47	99.00	0.54	32.74	5.75
R_Ank_Rot_Ang	-10.62	6.02	98.71	0.82	-42.81	12.95	76.51	1.92	-23.31	10.07
L_Ank_Rot_Ang	-9.18	8.51	98.70	0.93	-43.93	12.76	75.80	1.85	-24.35	11.87
R_Ank_Abd_Ang	3.38	1.09	66.51	1.31	-4.64	2.41	82.71	1.30	1.53	0.84
L_Ank_Abd_Ang	3.23	2.20	69.60	10.48	-4.66	2.98	82.40	2.13	1.20	1.58
R_Ank_Flex_Ang	6.11	1.98	87.31	2.98	-6.50	2.70	64.81	1.40	-4.28	2.86
L_Ank_Flex_Ang	5.88	2.97	87.30	3.45	-5.94	3.81	68.10	10.93	-3.56	3.42
R_Elbow_Ang	35.46	9.83	61.21	0.91	25.08	6.53	99.01	0.29	35.46	9.83
L_Elbow_Ang	37.26	9.44	60.80	1.22	24.61	4.79	99.10	0.31	37.26	9.44
R_Shl_Add_Ang	22.28	4.88	95.31	11.68	16.34	2.79	73.31	6.90	18.62	3.78
L_Shl_Add_Ang	21.86	3.94	95.20	11.55	14.23	3.53	72.80	6.06	15.96	3.98
R_Shl_Flex_Ang	-15.40	21.54	61.21	0.91	-59.29	14.25	99.01	0.29	-15.40	21.54
L_Shl_Flex_Ang	-9.35	10.42	60.80	1.22	-65.61	12.82	99.00	0.35	-9.35	10.42
R_Trunk_Lat_Tilt	0.81	2.23	63.01	4.00	-0.90	2.41	93.71	5.19	0.77	2.28
L_Trunk_Lat_Tilt	0.82	2.25	63.00	4.15	-0.90	2.41	93.80	5.14	0.75	2.30
R_Trunk_Fwd_Tilt	0.26	1.93	92.41	2.27	-1.97	2.44	70.21	10.42	-1.62	2.54
L_Trunk_Fwd_Tilt	0.26	1.93	92.50	2.45	-1.97	2.44	70.30	10.37	-1.55	2.50
R_Trunk_Rotation	4.91	3.94	61.51	1.48	-0.73	3.45	91.71	4.94	4.89	3.96
L_Trunk_Rotation	4.95	3.91	61.20	1.76	-0.73	3.45	91.80	4.85	4.92	3.94
R_Pelvis_Lat_Tilt	1.46	2.06	97.01	4.02	-5.28	2.86	65.91	1.37	-4.59	2.77
L_Pelvis_Lat_Tilt	1.46	2.06	97.10	4.09	-5.28	2.86	66.00	1.39	-4.44	2.80
R_Pelvis_Fwd_Tilt	11.76	2.42	83.61	13.30	9.79	3.12	79.81	16.66	10.81	2.67
L_Pelvis_Fwd_Tilt	11.76	2.42	83.70	13.41	9.80	3.13	82.40	15.21	10.83	2.66
R_Pelvis_Rotation	5.86	3.56	99.01	0.29	-4.97	2.37	65.21	5.08	-4.68	2.49
L_Pelvis_Rotation	5.86	3.56	99.10	0.31	-4.99	2.33	65.40	4.97	-4.65	2.48
R_Foot_Orientation	-7.79	4.22	73.21	18.02	-19.85	6.84	83.51	6.47	-9.07	4.12
L_Foot_Orientation	-10.43	5.19	65.80	11.77	-21.80	7.92	84.00	7.13	-10.89	5.24

Table B.11 Stance Phase Kinematics of 8-year-old Male Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Foot Strike		**Maximum Stance**		**Time of Max. St.**		**Minimum Stance**		**Time of Min. St.**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-4.76	9.20	9.68	11.09	51.40	13.70	-4.76	9.20	0.00	0.00
L_Hip_Rot_Ang	-8.35	13.06	7.24	10.91	51.60	7.18	-8.35	13.06	0.00	0.00
R_Hip_Abd_Ang	-0.92	2.11	6.08	2.04	19.50	2.12	-4.22	1.63	59.70	0.95
L_Hip_Abd_Ang	-0.41	2.72	7.28	2.72	20.50	2.72	-2.59	1.45	41.80	28.86
R_Hip_Flex_Ang	28.18	10.33	28.18	10.33	0.00	0.00	-17.57	8.58	52.80	1.03
L_Hip_Flex_Ang	28.75	10.96	28.75	10.96	0.00	0.00	-17.42	9.09	52.80	1.23
R_Knee_Rot_Ang	3.53	11.30	18.71	11.35	45.90	22.73	-0.35	13.96	21.40	22.96
L_Knee_Rot_Ang	1.04	16.42	16.21	14.60	45.30	22.65	-4.58	12.66	25.00	22.15
R_Knee_Abd_Ang	-1.80	1.61	3.02	4.20	49.90	15.20	-3.03	2.97	25.60	24.34
L_Knee_Abd_Ang	-2.21	2.18	1.96	3.95	38.20	21.17	-3.42	2.52	31.60	27.53
R_Knee_Flex_Ang	4.16	3.64	30.95	4.55	59.70	0.95	1.13	3.75	28.70	19.86
L_Knee_Flex_Ang	4.96	4.11	32.00	4.69	59.80	0.92	1.49	4.26	32.70	17.29
R_Ank_Rot_Ang	-13.26	5.63	-10.16	8.05	26.60	23.23	-34.15	8.05	23.00	19.78
L_Ank_Rot_Ang	-8.90	12.20	-4.86	8.68	25.50	22.29	-28.32	11.75	22.80	19.62
R_Ank_Abd_Ang	-1.05	0.87	0.12	1.20	41.70	26.96	-5.44	2.20	31.00	15.55
L_Ank_Abd_Ang	-1.18	1.90	-0.03	1.01	34.70	29.18	-4.41	2.88	28.90	15.60
R_Ank_Flex_Ang	4.50	3.81	15.96	3.70	44.30	0.95	0.34	2.62	43.20	26.87
L_Ank_Flex_Ang	3.96	3.06	17.30	2.77	44.50	1.08	0.69	2.64	37.60	28.94
R_Elbow_Ang	20.72	4.77	42.94	6.50	50.70	3.06	19.75	4.44	5.80	3.16
L_Elbow_Ang	21.99	5.25	40.50	11.88	52.30	3.27	20.99	5.19	6.70	3.13
R_Shl_Add_Ang	25.32	4.34	26.48	5.40	15.80	24.11	17.34	2.40	31.90	10.93
L_Shl_Add_Ang	26.73	7.77	27.69	8.41	10.20	20.55	17.13	4.29	31.10	11.60
R_Shl_Flex_Ang	-67.70	11.96	4.26	23.92	49.00	2.94	-68.07	11.89	2.80	1.87
L_Shl_Flex_Ang	-71.25	12.58	-0.06	29.98	49.10	1.60	-71.59	12.78	2.50	2.01
R_Trunk_Lat_Tilt	-0.70	2.70	1.04	2.29	44.30	18.45	-1.01	2.70	10.30	14.14
L_Trunk_Lat_Tilt	-0.70	2.70	1.03	2.31	44.10	18.25	-1.01	2.70	10.30	14.14
R_Trunk_Fwd_Tilt	0.20	2.29	1.22	2.21	38.40	13.63	-2.10	2.66	32.70	23.97
L_Trunk_Fwd_Tilt	0.20	2.29	1.22	2.21	38.40	13.63	-2.04	2.62	27.70	21.42
R_Trunk_Rotation	-0.11	3.01	5.93	3.61	46.00	9.56	-0.46	3.21	3.90	5.38
L_Trunk_Rotation	-0.11	3.01	5.91	3.63	45.90	9.39	-0.46	3.21	3.90	5.38
R_Pelvis_Lat_Tilt	1.92	2.52	5.70	2.84	15.00	1.05	-4.30	2.73	60.20	0.92
L_Pelvis_Lat_Tilt	1.92	2.52	5.70	2.84	15.00	1.05	-4.15	2.75	59.70	1.16
R_Pelvis_Fwd_Tilt	11.13	2.57	12.41	2.28	19.50	17.88	10.07	2.64	32.60	25.77
L_Pelvis_Fwd_Tilt	11.13	2.57	12.41	2.28	19.50	17.88	10.11	2.62	32.40	25.54
R_Pelvis_Rotation	5.99	3.31	6.96	3.14	9.60	7.99	-5.16	2.26	56.30	4.06
L_Pelvis_Rotation	5.99	3.31	6.96	3.14	9.60	7.99	-5.12	2.31	55.70	3.33
R_Foot_Orientation	-8.66	3.96	-4.29	2.93	16.60	5.93	-10.23	3.28	29.10	30.74
L_Foot_Orientation	-13.54	6.15	-8.65	5.62	30.70	20.11	-14.48	5.67	14.30	23.77

Table B.12 Swing Phase Kinematics of 8-year-old Male Subjects
(Max = Maximum, Sw. = Swing, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Maximum Swing		**Time of Max. Sw.**		**Minimum Swing**		**Time of Min. Sw.**		**Toe Off**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	9.60	10.87	66.44	8.56	-5.62	9.07	98.34	0.78	9.03	11.41
L_Hip_Rot_Ang	6.27	10.74	65.33	7.89	-9.49	12.99	98.43	0.85	5.71	10.67
R_Hip_Abd_Ang	-0.61	1.91	85.94	5.16	-5.25	1.73	64.54	1.76	-4.55	1.64
L_Hip_Abd_Ang	-0.14	2.24	88.13	7.68	-3.66	1.83	68.73	10.37	-2.74	1.48
R_Hip_Flex_Ang	28.16	10.00	91.94	2.24	-11.96	8.11	60.64	0.86	-11.96	8.11
L_Hip_Flex_Ang	28.73	10.45	91.93	3.26	-11.67	8.23	60.83	0.95	-11.67	8.23
R_Knee_Rot_Ang	33.81	10.66	71.84	3.92	0.65	10.89	93.64	11.86	17.58	14.01
L_Knee_Rot_Ang	30.39	14.12	70.73	4.05	-2.93	14.45	93.23	11.94	15.70	15.97
R_Knee_Abd_Ang	7.80	5.81	80.64	7.80	-3.55	3.77	89.34	15.23	2.16	6.61
L_Knee_Abd_Ang	7.12	7.29	82.93	5.66	-4.73	5.36	85.53	17.90	0.02	5.96
R_Knee_Flex_Ang	64.99	2.47	73.74	0.99	3.24	4.18	98.94	0.30	34.37	4.51
L_Knee_Flex_Ang	66.06	2.76	73.93	1.12	3.59	4.30	99.03	0.25	35.44	4.69
R_Ank_Rot_Ang	-10.83	5.86	98.44	0.97	-45.02	13.69	76.04	1.85	-27.22	11.95
L_Ank_Rot_Ang	-6.14	11.09	98.33	1.06	-40.33	11.02	75.63	1.92	-22.52	12.43
R_Ank_Abd_Ang	1.70	1.83	68.54	10.71	-6.33	1.99	81.44	1.46	0.26	1.30
L_Ank_Abd_Ang	0.98	1.38	72.03	14.12	-6.33	3.08	80.93	1.34	-0.19	1.13
R_Ank_Flex_Ang	8.14	2.70	87.84	3.92	-2.51	2.68	64.34	0.98	-0.46	2.75
L_Ank_Flex_Ang	8.64	1.94	86.73	3.86	-2.26	2.67	64.63	1.07	-0.02	2.80
R_Elbow_Ang	39.87	6.56	60.64	0.86	21.05	4.74	98.74	0.71	39.87	6.56
L_Elbow_Ang	38.76	10.89	62.83	6.89	21.70	5.42	95.43	10.95	38.59	11.19
R_Shl_Add_Ang	25.13	4.69	90.74	16.07	19.27	3.97	72.64	5.03	22.23	5.44
L_Shl_Add_Ang	27.20	7.99	94.23	11.72	17.91	5.46	72.53	5.83	21.39	8.14
R_Shl_Flex_Ang	-5.23	23.06	60.64	0.86	-66.90	12.89	98.94	0.30	-5.23	23.06
L_Shl_Flex_Ang	-9.02	27.55	60.83	0.95	-71.50	12.18	99.03	0.25	-9.02	27.55
R_Trunk_Lat_Tilt	1.75	2.65	63.54	3.15	-1.65	1.52	98.04	2.73	1.68	2.67
L_Trunk_Lat_Tilt	1.76	2.64	63.43	3.38	-1.65	1.52	98.13	2.99	1.70	2.67
R_Trunk_Fwd_Tilt	-0.96	2.21	88.24	10.02	-3.19	2.70	66.74	5.59	-2.87	2.98
L_Trunk_Fwd_Tilt	-0.97	2.19	92.13	2.84	-3.19	2.70	66.83	5.60	-2.87	2.96
R_Trunk_Rotation	-0.02	2.15	60.84	1.12	-4.13	3.71	88.24	8.41	-0.03	2.15
L_Trunk_Rotation	-0.04	2.14	61.13	1.16	-4.13	3.71	88.33	8.43	-0.05	2.13
R_Pelvis_Lat_Tilt	-0.04	1.40	93.74	6.86	-3.97	1.23	65.74	1.72	-3.32	1.14
L_Pelvis_Lat_Tilt	-0.04	1.40	93.83	6.80	-3.97	1.23	65.83	1.80	-3.35	1.31
R_Pelvis_Fwd_Tilt	4.83	7.88	90.94	9.21	3.37	7.65	68.14	5.23	3.73	7.68
L_Pelvis_Fwd_Tilt	4.83	7.88	91.03	9.30	3.37	7.65	68.23	5.35	3.71	7.68
R_Pelvis_Rotation	7.61	2.71	98.94	0.30	-6.18	3.01	60.84	1.26	-6.17	3.00
L_Pelvis_Rotation	7.61	2.71	99.03	0.25	-6.16	2.98	61.03	1.40	-6.15	2.98
R_Foot_Orientation	-5.32	6.67	73.84	17.98	-14.21	4.49	79.14	8.46	-6.24	7.51
L_Foot_Orientation	-5.95	8.17	70.13	15.62	-17.90	6.16	84.93	6.88	-6.82	8.61

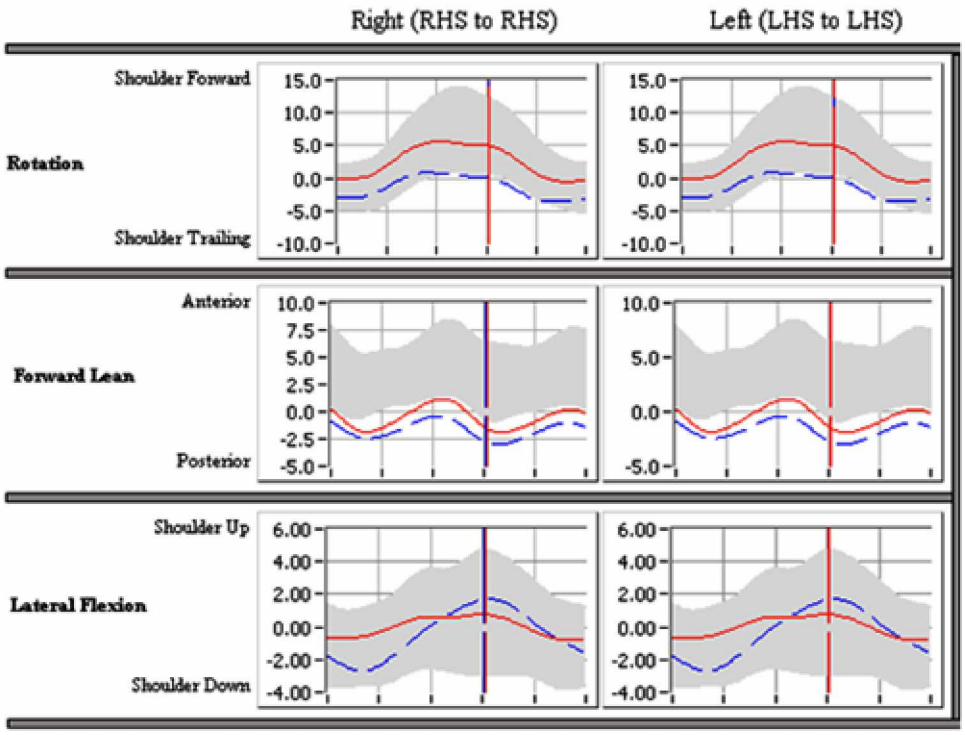

Figure B.15 Trunk Orientation Relative to Room (Degrees), 8-year-old subjects.

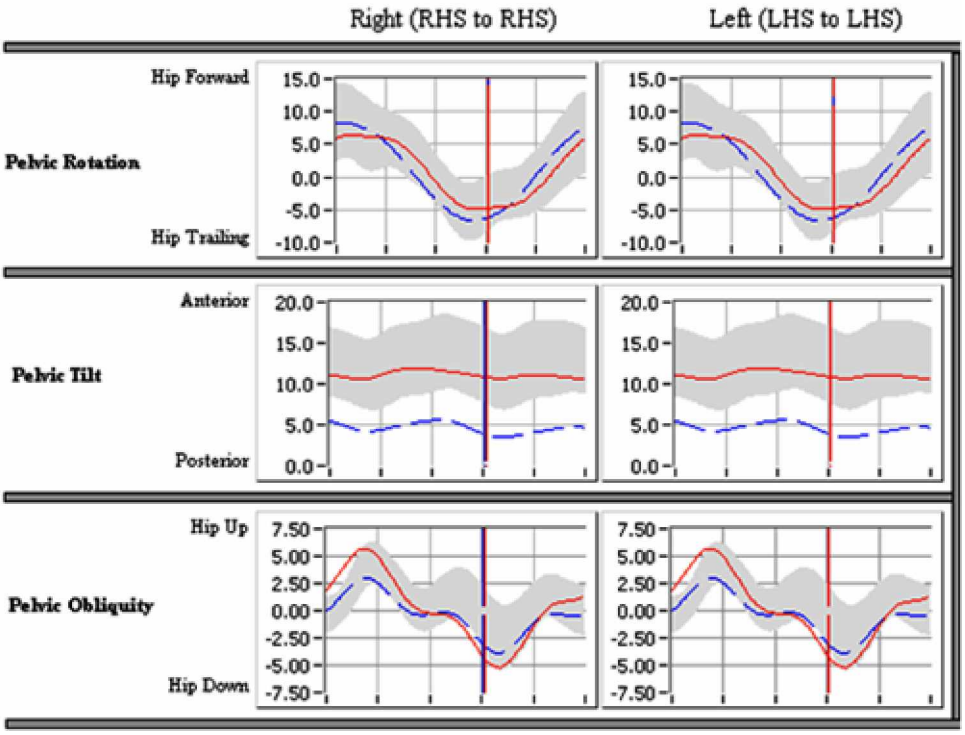

Figure B.16 Pelvis Orientation Relative to Room (Degrees), 8-year-old subjects.

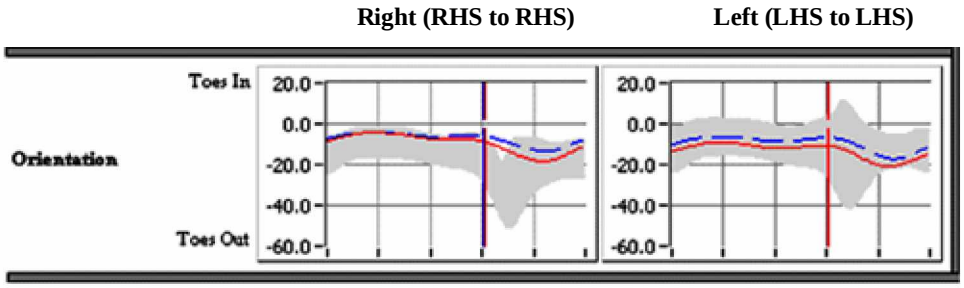

Figure B.17 Foot Orientation Relative to Room (Degrees), 8-year-old subjects.

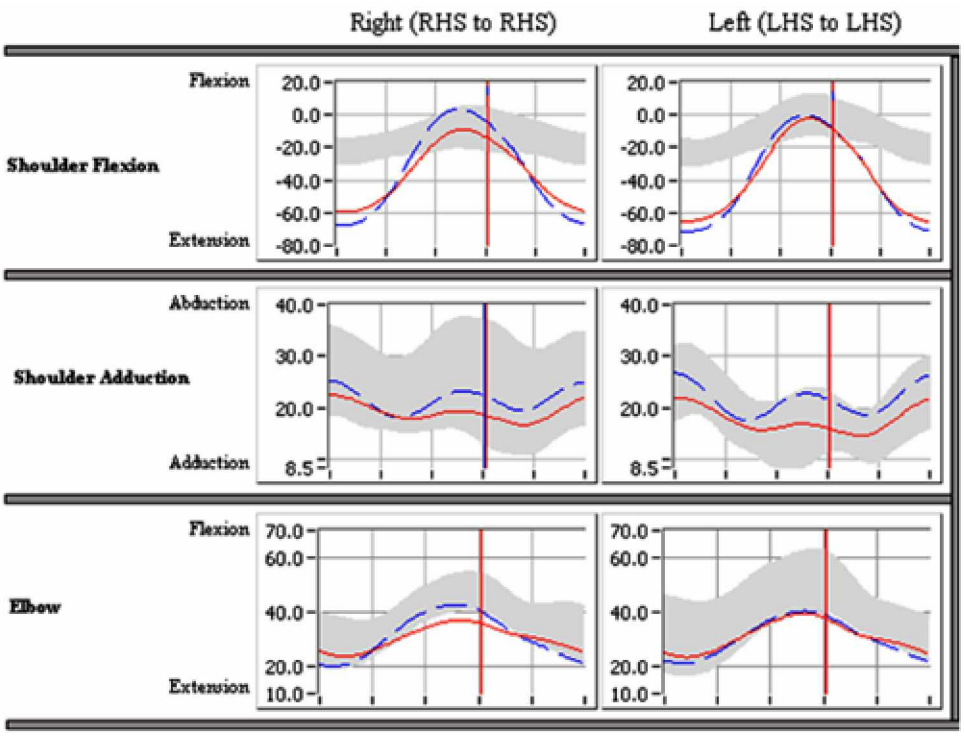

Figure B.18 Arm Joint Angles (Degrees), 8-year-old subjects.

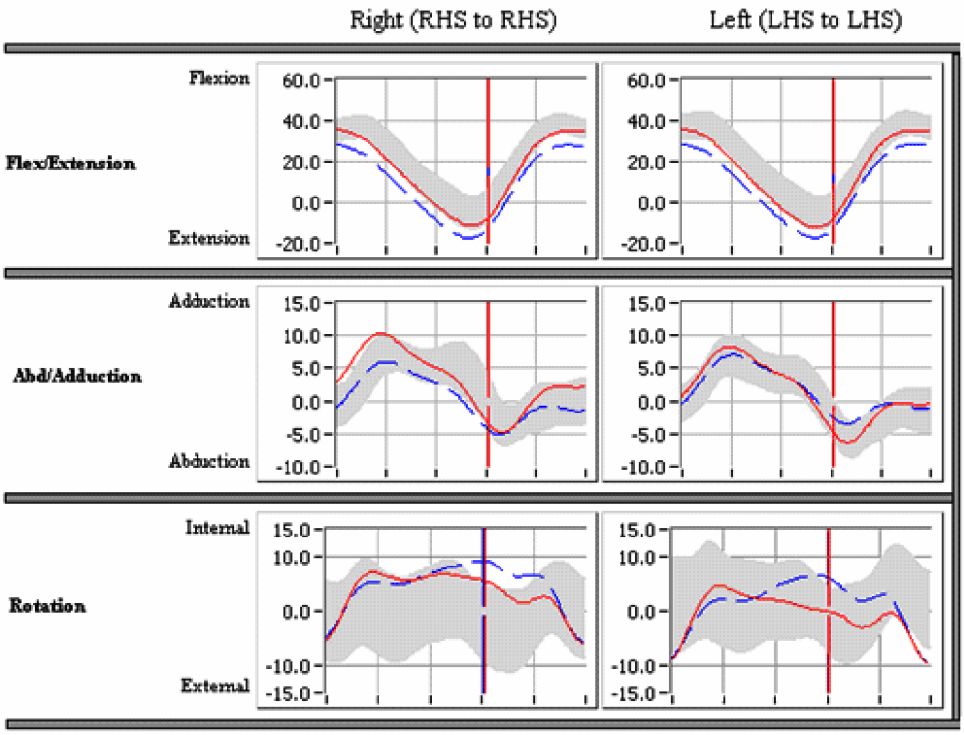

Figure B.19 Hip Joint Angles (Degrees), 8-year-old subjects.

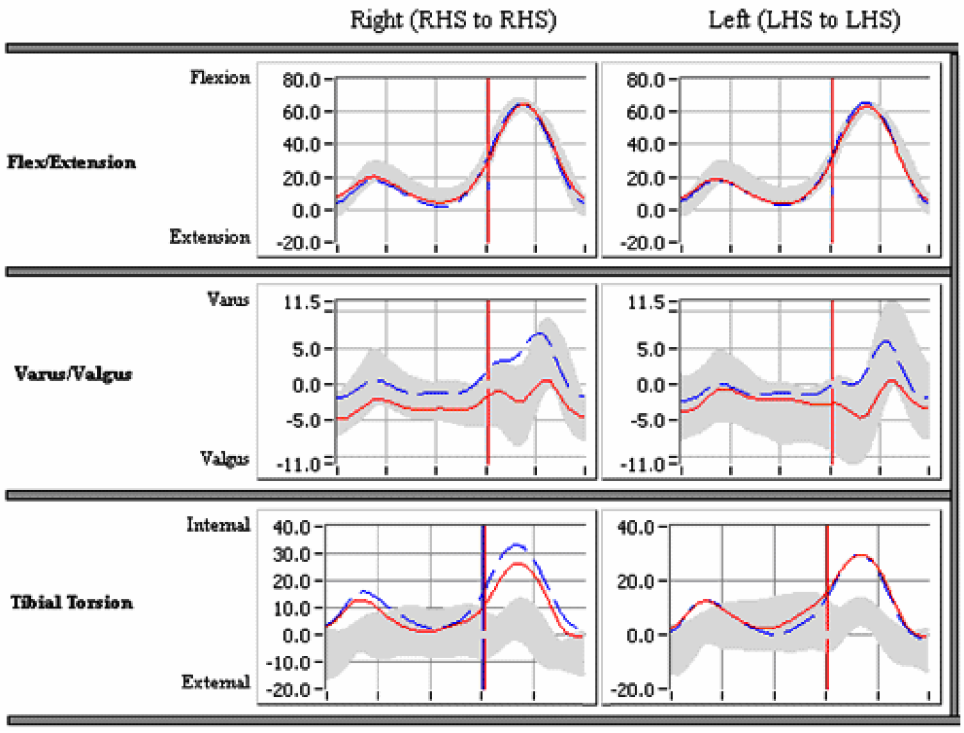

Figure B.20 Knee Joint Angles (Degrees), 8-year-old subjects.

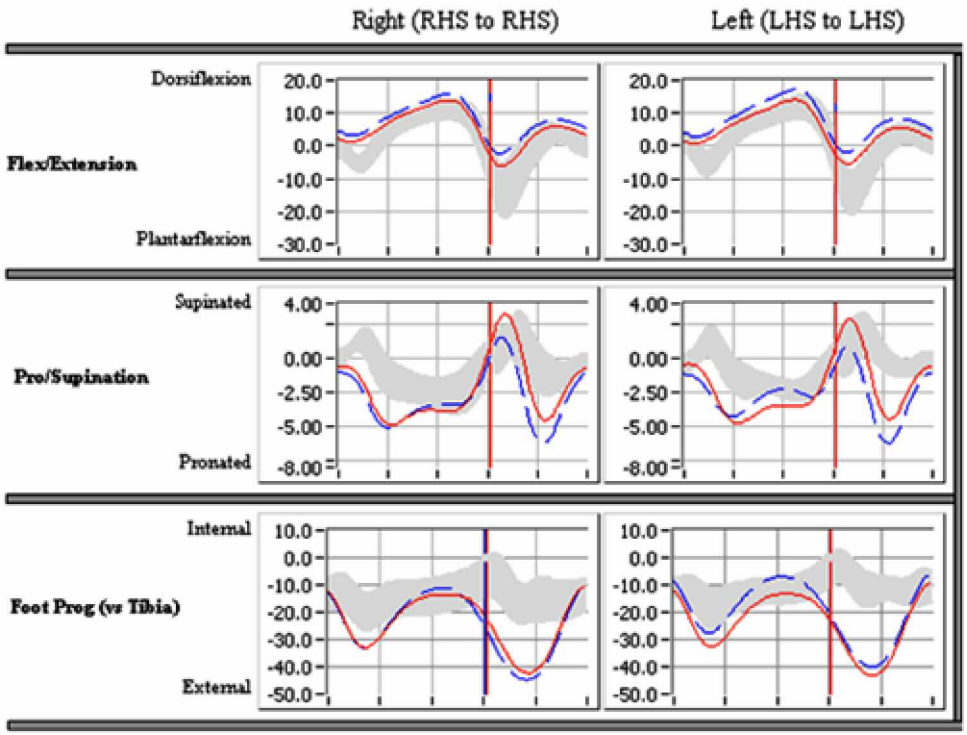

Figure B.21 Ankle Joint Angles (Degrees), 8-year-old subjects.

Nine-Year-Old Subjects

Table B.13 Stance Phase Kinematics of 9-year-old Female Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-9.91	6.86	6.02	6.50	43.30	14.76	-9.91	6.86	0.00	0.00
L_Hip_Rot_Ang	-8.83	4.03	7.05	4.07	38.30	14.67	-8.83	4.03	0.00	0.00
R_Hip_Abd_Ang	0.83	2.96	8.70	2.46	18.10	1.20	-3.07	2.54	59.80	1.48
L_Hip_Abd_Ang	1.90	1.87	9.35	2.25	17.50	1.51	-3.45	2.25	59.40	1.07
R_Hip_Flex_Ang	34.55	3.53	34.57	3.53	0.60	1.26	-11.06	4.29	53.50	1.90
L_Hip_Flex_Ang	34.83	3.76	34.85	3.75	0.50	0.85	-9.50	3.71	52.90	1.37
R_Knee_Rot_Ang	0.07	11.77	14.78	11.90	44.90	21.82	-3.94	11.11	25.90	22.71
L_Knee_Rot_Ang	4.31	11.80	19.20	8.66	49.20	18.82	0.32	11.64	19.70	20.01
R_Knee_Abd_Ang	-3.23	2.23	0.72	3.09	41.60	23.14	-3.88	2.41	18.00	21.86
L_Knee_Abd_Ang	-4.32	1.97	-0.47	2.81	37.40	22.80	-4.57	2.05	24.90	24.79
R_Knee_Flex_Ang	3.94	4.88	29.43	5.55	59.80	1.48	0.80	4.13	24.60	21.00
L_Knee_Flex_Ang	4.75	5.60	31.31	5.38	59.40	1.07	1.81	4.46	23.80	20.13
R_Ank_Rot_Ang	-10.97	10.91	-9.29	10.72	16.80	21.78	-31.87	13.20	27.70	23.02
L_Ank_Rot_Ang	-12.70	6.86	-10.18	5.92	17.60	22.49	-31.65	5.34	22.70	19.18
R_Ank_Abd_Ang	-1.02	1.30	0.27	1.12	48.60	23.00	-5.48	2.27	34.00	15.45
L_Ank_Abd_Ang	-1.10	1.10	0.27	0.70	48.20	23.32	-5.87	1.54	33.80	14.68
R_Ank_Flex_Ang	2.77	3.14	15.28	4.01	44.20	2.94	-1.76	2.77	43.10	26.08
L_Ank_Flex_Ang	3.61	3.41	16.49	2.87	43.70	2.36	-0.46	1.05	48.10	23.54
R_Elbow_Ang	26.46	4.29	44.13	5.51	50.70	6.22	25.20	4.09	7.10	2.60
L_Elbow_Ang	24.73	5.79	46.80	7.31	51.90	5.28	23.80	5.57	6.20	2.39
R_Shl_Add_Ang	22.42	4.60	23.17	4.38	21.10	26.64	16.72	4.41	32.00	15.72
L_Shl_Add_Ang	23.39	5.93	23.78	5.74	10.10	20.57	12.86	3.41	39.10	16.22
R_Shl_Flex_Ang	-54.75	14.72	2.18	25.09	46.50	10.21	-55.37	14.87	8.30	18.71
L_Shl_Flex_Ang	-67.91	12.01	11.06	25.28	49.10	3.60	-68.33	12.40	2.40	4.60
R_Trunk_Lat_Tilt	0.00	1.54	1.68	1.92	38.80	20.75	-0.58	1.82	16.80	18.97
L_Trunk_Lat_Tilt	0.00	1.54	1.66	1.93	38.60	20.52	-0.58	1.82	16.80	18.97
R_Trunk_Fwd_Tilt	-0.57	1.57	-0.14	1.56	28.20	19.53	-3.71	1.83	55.00	14.82
L_Trunk_Fwd_Tilt	-0.57	1.57	-0.14	1.56	28.20	19.53	-3.65	1.71	54.70	14.69
R_Trunk_Rotation	0.11	4.35	5.15	4.53	41.70	9.84	-0.32	4.29	11.70	16.75
L_Trunk_Rotation	0.11	4.35	5.15	4.53	41.70	9.84	-0.32	4.29	11.70	16.75
R_Pelvis_Lat_Tilt	1.33	0.90	5.04	1.25	15.00	1.33	-3.94	1.76	59.80	1.48
L_Pelvis_Lat_Tilt	1.33	0.90	5.04	1.25	15.00	1.33	-3.81	1.60	59.40	1.07
R_Pelvis_Fwd_Tilt	11.81	3.30	12.65	3.08	20.40	17.96	10.09	3.36	40.20	25.81
L_Pelvis_Fwd_Tilt	11.81	3.30	12.65	3.08	20.40	17.96	10.13	3.36	39.90	25.54
R_Pelvis_Rotation	8.10	5.04	8.22	4.98	2.70	5.31	-4.43	1.29	51.20	1.55
L_Pelvis_Rotation	8.10	5.04	8.22	4.98	2.70	5.31	-4.43	1.29	52.00	3.20
R_Foot_Orientation	-12.82	4.45	-8.32	4.20	24.30	12.57	-13.61	4.44	22.10	28.32
L_Foot_Orientation	-12.26	6.83	-7.85	5.58	25.10	19.43	-13.13	5.61	21.30	27.73

Table B.14 Swing Phase Kinematics of 9-year-old Female Subjects
(Max = Maximum, Sw. = Swing, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Maximum Swing		**Time of Max. Sw.**		**Minimum Swing**		**Time of Min. Sw.**		**Toe Off**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	5.13	6.57	62.01	2.03	-9.94	6.64	98.61	1.00	5.02	6.59
L_Hip_Rot_Ang	4.36	4.66	67.07	10.52	-10.32	3.88	98.47	0.96	4.13	4.83
R_Hip_Abd_Ang	0.50	2.84	92.11	7.70	-5.24	2.41	66.91	1.60	-3.57	2.52
L_Hip_Abd_Ang	1.19	1.56	93.07	7.81	-5.49	1.69	66.07	1.91	-3.95	2.20
R_Hip_Flex_Ang	34.32	2.97	91.81	4.24	-6.11	4.30	60.91	1.35	-6.11	4.30
L_Hip_Flex_Ang	34.20	4.30	93.27	4.70	-4.50	3.88	60.47	1.00	-4.50	3.88
R_Knee_Rot_Ang	28.45	15.52	76.41	8.33	-3.54	12.05	95.61	7.43	13.21	14.28
L_Knee_Rot_Ang	34.77	12.43	72.47	2.87	1.11	12.50	95.47	4.11	19.00	10.89
R_Knee_Abd_Ang	2.88	4.00	74.91	10.22	-4.30	2.06	88.61	13.29	0.68	3.41
L_Knee_Abd_Ang	1.89	3.21	75.37	10.49	-5.69	1.25	85.17	14.10	-1.18	3.21
R_Knee_Flex_Ang	64.46	4.28	74.31	0.93	2.94	4.96	99.11	0.24	32.71	5.53
L_Knee_Flex_Ang	65.70	5.12	73.77	1.09	3.33	6.17	99.07	0.24	34.56	5.58
R_Ank_Rot_Ang	-8.84	10.87	98.41	0.86	-42.99	16.17	76.71	2.37	-28.02	14.94
L_Ank_Rot_Ang	-10.23	7.42	98.57	0.80	-45.85	11.46	75.77	1.95	-28.15	7.22
R_Ank_Abd_Ang	2.26	2.05	65.71	1.74	-5.69	3.06	82.11	1.37	0.65	1.44
L_Ank_Abd_Ang	2.80	2.22	65.47	1.92	-5.92	2.25	81.47	1.72	0.73	1.15
R_Ank_Flex_Ang	7.08	2.34	85.91	3.37	-5.30	4.32	65.11	1.96	-2.44	2.92
L_Ank_Flex_Ang	7.60	2.58	87.97	4.14	-4.25	3.23	64.57	1.90	-1.33	1.64
R_Elbow_Ang	40.14	7.30	60.91	1.35	26.01	5.59	96.81	7.33	40.14	7.30
L_Elbow_Ang	42.86	8.91	60.47	1.00	23.91	5.86	99.07	0.24	42.86	8.91
R_Shl_Add_Ang	22.64	3.71	89.51	15.76	16.65	4.34	72.91	5.70	18.74	4.03
L_Shl_Add_Ang	22.69	4.91	93.87	11.80	12.94	3.00	70.07	6.64	15.99	5.73
R_Shl_Flex_Ang	-8.87	27.18	60.91	1.35	-56.96	14.96	96.21	5.56	-8.87	27.18
L_Shl_Flex_Ang	-3.04	26.17	60.47	1.00	-70.39	10.25	97.77	1.99	-3.04	26.17
R_Trunk_Lat_Tilt	1.45	1.65	70.91	15.47	-0.31	1.22	90.31	12.28	1.24	1.86
L_Trunk_Lat_Tilt	1.44	1.65	70.87	15.34	-0.30	1.22	90.37	12.26	1.21	1.87
R_Trunk_Fwd_Tilt	-0.92	1.17	92.01	2.26	-3.88	1.68	63.91	2.35	-3.71	1.81
L_Trunk_Fwd_Tilt	-0.92	1.17	91.97	2.39	-3.88	1.68	63.87	2.41	-3.66	1.72
R_Trunk_Rotation	4.12	4.41	68.81	16.00	-0.62	4.01	89.21	6.54	3.97	4.58
L_Trunk_Rotation	4.12	4.43	68.57	16.13	-0.62	4.01	89.17	6.45	3.97	4.60
R_Pelvis_Lat_Tilt	0.85	1.14	96.01	5.01	-4.85	1.78	65.61	1.01	-4.21	1.78
L_Pelvis_Lat_Tilt	0.85	1.14	95.97	4.98	-4.85	1.78	65.57	1.02	-4.09	1.64
R_Pelvis_Fwd_Tilt	11.30	2.95	85.21	14.44	9.72	3.40	77.01	15.54	10.51	3.39
L_Pelvis_Fwd_Tilt	11.31	2.96	85.17	14.43	9.72	3.40	76.97	15.58	10.56	3.39
R_Pelvis_Rotation	7.68	4.94	99.11	0.24	-3.12	1.46	62.81	4.34	-3.07	1.36
L_Pelvis_Rotation	7.68	4.94	99.07	0.24	-3.24	1.34	61.47	3.39	-3.19	1.25
R_Foot_Orientation	-11.35	4.52	73.91	17.51	-18.87	4.64	82.11	7.59	-12.04	4.61
L_Foot_Orientation	-9.35	6.32	72.97	18.01	-19.40	5.12	81.67	5.35	-9.73	6.57

Table B.15 Stance Phase Kinematics of 9-year-old Male Subjects
(Max = Maximum, Sw. = Swing, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd =Forward)

	Foot Strike		**Maximum Stance**		**Time of Max. St.**		**Minimum Stance**		**Time of Min. St.**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-8.79	5.72	7.25	7.17	49.60	12.83	-8.79	5.72	0.00	0.00
L_Hip_Rot_Ang	-8.14	5.41	8.13	8.81	35.10	18.53	-8.14	5.41	0.00	0.00
R_Hip_Abd_Ang	-1.29	2.42	6.47	3.38	20.60	1.96	-3.31	2.53	53.80	18.94
L_Hip_Abd_Ang	-1.83	1.81	5.85	2.72	20.50	2.01	-4.68	2.05	53.60	18.86
R_Hip_Flex_Ang	31.10	4.93	31.10	4.93	0.10	0.32	-11.86	4.32	52.90	1.97
L_Hip_Flex_Ang	32.67	5.31	32.68	5.31	0.20	0.63	-11.35	4.99	52.50	1.51
R_Knee_Rot_Ang	4.19	10.19	17.35	9.49	36.50	25.00	-0.67	10.34	30.80	21.93
L_Knee_Rot_Ang	-1.65	11.06	14.19	9.60	55.10	15.18	-4.07	11.70	14.60	19.47
R_Knee_Abd_Ang	-1.96	2.28	2.27	4.80	38.80	23.91	-2.38	2.55	12.70	23.67
L_Knee_Abd_Ang	-2.08	2.16	2.73	2.44	33.30	23.01	-2.47	2.25	17.00	26.09
R_Knee_Flex_Ang	4.49	5.03	30.73	4.83	59.80	1.14	1.17	4.54	24.50	20.93
L_Knee_Flex_Ang	5.65	4.92	32.63	4.89	59.70	1.16	2.22	4.30	28.60	19.80
R_Ank_Rot_Ang	-12.30	6.70	-9.34	4.43	27.00	23.54	-30.21	7.73	23.30	19.36
L_Ank_Rot_Ang	-6.20	10.60	-4.26	10.11	25.20	21.72	-26.48	9.22	23.20	19.69
R_Ank_Abd_Ang	-0.63	1.15	0.83	1.61	43.60	25.76	-3.40	1.35	34.90	14.73
L_Ank_Abd_Ang	-0.51	1.06	0.47	0.70	39.50	26.06	-3.65	2.46	35.20	18.14
R_Ank_Flex_Ang	2.17	4.41	13.37	3.85	43.90	1.73	-2.12	3.22	43.80	25.45
L_Ank_Flex_Ang	2.33	2.99	14.39	3.55	44.40	0.84	-1.23	2.81	43.70	25.82
R_Elbow_Ang	24.60	6.52	46.64	9.55	51.30	5.12	23.26	6.46	7.20	2.15
L_Elbow_Ang	21.74	8.41	46.08	9.98	51.80	4.83	20.38	7.96	6.80	3.12
R_Shl_Add_Ang	25.11	5.29	25.80	5.82	11.10	22.65	16.07	3.68	33.60	6.20
L_Shl_Add_Ang	27.43	6.26	28.63	6.59	11.70	23.41	15.69	3.91	36.00	11.61
R_Shl_Flex_Ang	-64.17	14.15	-0.50	15.64	49.20	1.81	-64.79	14.01	3.60	3.47
L_Shl_Flex_Ang	-65.65	12.45	19.66	23.66	50.00	1.56	-66.18	12.29	3.70	2.45
R_Trunk_Lat_Tilt	-1.05	2.17	1.34	1.55	58.60	2.55	-2.34	2.21	14.80	7.97
L_Trunk_Lat_Tilt	-1.05	2.17	1.33	1.56	58.70	2.67	-2.34	2.21	14.80	7.97
R_Trunk_Fwd_Tilt	0.31	3.29	0.67	3.29	20.20	21.35	-2.14	3.79	41.10	23.80
L_Trunk_Fwd_Tilt	0.31	3.29	0.67	3.29	20.20	21.35	-2.13	3.76	41.20	23.89
R_Trunk_Rotation	1.09	3.12	4.97	3.68	36.40	22.91	-0.38	3.21	22.60	24.31
L_Trunk_Rotation	1.09	3.12	4.97	3.68	36.30	22.80	-0.42	3.23	22.80	24.65
R_Pelvis_Lat_Tilt	0.89	1.36	4.43	2.05	15.70	1.95	-2.38	1.62	59.80	1.14
L_Pelvis_Lat_Tilt	0.89	1.36	4.43	2.05	15.70	1.95	-2.35	1.43	59.70	1.16
R_Pelvis_Fwd_Tilt	9.16	4.04	9.90	3.74	39.60	15.41	8.03	3.85	26.10	23.55
L_Pelvis_Fwd_Tilt	9.16	4.04	9.91	3.75	39.70	15.56	8.04	3.87	26.00	23.39
R_Pelvis_Rotation	9.03	3.76	9.17	3.69	3.30	3.71	-6.34	2.24	52.40	2.59
L_Pelvis_Rotation	9.03	3.76	9.17	3.69	3.30	3.71	-6.37	2.24	52.70	3.37
R_Foot_Orientation	-8.22	5.83	-5.44	5.97	20.20	13.68	-10.33	6.76	35.50	30.57
L_Foot_Orientation	-10.50	5.72	-7.08	5.95	28.70	22.18	-12.46	5.72	33.60	29.27

Table B.16 Swing Phase Kinematics of 9-year-old Male Subjects
(Max = Maximum, Sw. = Swing, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Maximum Swing		**Time of Max. Sw.**		**Minimum Swing**		**Time of Min. Sw.**		**Toe Off**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	5.94	7.51	64.98	8.76	-9.37	5.62	98.68	0.39	5.68	7.85
L_Hip_Rot_Ang	5.78	7.89	70.94	10.82	-9.56	5.10	98.54	0.70	3.80	8.32
R_Hip_Abd_Ang	-0.87	2.03	81.98	12.49	-4.89	2.04	66.48	2.98	-3.67	2.48
L_Hip_Abd_Ang	-1.40	1.91	85.34	12.01	-6.01	2.11	68.84	10.31	-4.93	2.03
R_Hip_Flex_Ang	31.38	4.98	92.58	2.92	-6.59	5.05	60.88	1.04	-6.59	5.05
L_Hip_Flex_Ang	32.77	5.31	93.14	3.55	-5.88	5.38	60.74	1.01	-5.88	5.38
R_Knee_Rot_Ang	32.82	12.01	72.88	1.68	2.23	10.14	96.88	3.62	17.15	11.03
L_Knee_Rot_Ang	29.27	8.95	72.14	1.32	-3.41	11.73	96.34	4.32	15.53	9.71
R_Knee_Abd_Ang	5.76	6.18	80.68	3.34	-2.56	2.52	85.98	14.94	1.67	5.77
L_Knee_Abd_Ang	6.27	4.17	79.24	6.19	-3.39	2.09	90.34	13.78	1.00	3.63
R_Knee_Flex_Ang	62.42	4.90	73.88	1.06	3.65	5.16	99.08	0.27	33.94	5.04
L_Knee_Flex_Ang	63.43	3.91	73.44	1.15	4.86	5.38	98.94	0.32	35.89	5.08
R_Ank_Rot_Ang	-11.14	6.94	98.98	0.33	-46.21	12.91	75.48	1.78	-27.68	8.12
L_Ank_Rot_Ang	-3.63	10.74	98.84	0.56	-40.31	11.79	74.54	1.79	-23.45	11.05
R_Ank_Abd_Ang	2.93	3.96	68.78	10.68	-5.30	2.81	81.48	2.00	1.12	2.10
L_Ank_Abd_Ang	2.00	2.31	79.24	17.07	-5.00	2.44	80.64	2.11	0.22	1.42
R_Ank_Flex_Ang	6.49	2.88	86.98	4.73	-4.57	5.76	64.28	0.90	-2.63	4.08
L_Ank_Flex_Ang	7.42	2.96	85.94	3.72	-2.98	4.97	67.94	10.97	-1.14	4.22
R_Elbow_Ang	44.29	10.07	63.28	7.15	23.85	6.21	95.98	9.67	44.27	10.08
L_Elbow_Ang	43.32	10.15	60.74	1.01	21.24	8.39	96.34	8.72	43.32	10.15
R_Shl_Add_Ang	25.58	5.15	89.88	15.00	17.16	3.49	68.68	7.64	19.57	5.64
L_Shl_Add_Ang	27.60	6.90	90.94	15.52	16.00	4.54	71.64	9.02	20.07	6.52
R_Shl_Flex_Ang	-11.16	14.57	60.88	1.04	-64.96	15.28	99.08	0.27	-11.16	14.57
L_Shl_Flex_Ang	8.14	21.36	60.74	1.01	-65.38	12.94	99.04	0.30	8.14	21.36
R_Trunk_Lat_Tilt	1.70	1.72	66.88	4.23	-1.00	1.93	96.68	3.95	1.36	1.56
L_Trunk_Lat_Tilt	1.71	1.72	66.64	4.43	-1.00	1.93	96.64	4.18	1.36	1.57
R_Trunk_Fwd_Tilt	0.08	3.06	92.68	3.79	-2.46	3.80	67.08	6.01	-2.05	3.80
L_Trunk_Fwd_Tilt	0.08	3.06	92.64	3.84	-2.45	3.80	67.24	6.02	-2.01	3.79
R_Trunk_Rotation	4.54	4.01	76.68	19.11	0.25	4.12	82.98	14.23	3.04	4.65
L_Trunk_Rotation	4.56	3.98	76.54	19.17	0.23	4.12	82.84	14.28	3.01	4.68
R_Pelvis_Lat_Tilt	0.64	1.23	96.38	5.69	-3.57	1.52	66.78	1.49	-2.67	1.60
L_Pelvis_Lat_Tilt	0.64	1.23	96.34	6.05	-3.57	1.52	66.74	1.45	-2.64	1.44
R_Pelvis_Fwd_Tilt	9.12	3.86	80.88	14.09	7.81	3.87	85.38	15.23	8.47	3.74
L_Pelvis_Fwd_Tilt	9.10	3.87	81.04	13.87	7.81	3.87	85.34	15.12	8.49	3.75
R_Pelvis_Rotation	9.55	4.32	99.08	0.27	-5.29	2.38	61.58	1.64	-5.25	2.36
L_Pelvis_Rotation	9.55	4.32	99.04	0.30	-5.37	2.40	61.24	1.72	-5.36	2.40
R_Foot_Orientation	-7.57	6.14	87.68	18.41	-16.54	5.22	77.68	9.06	-9.67	7.20
L_Foot_Orientation	-9.18	5.88	81.94	18.34	-17.57	4.93	81.54	9.16	-11.03	6.61

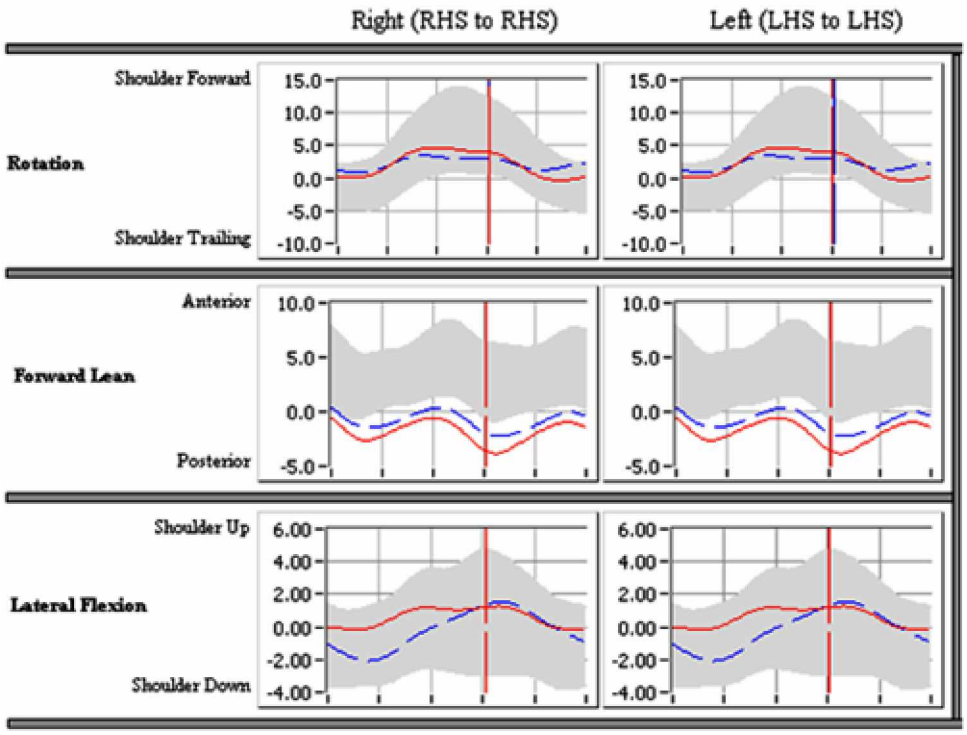

Figure B.22 Trunk Orientation Relative to Room (Degrees), 9-year-old subjects.

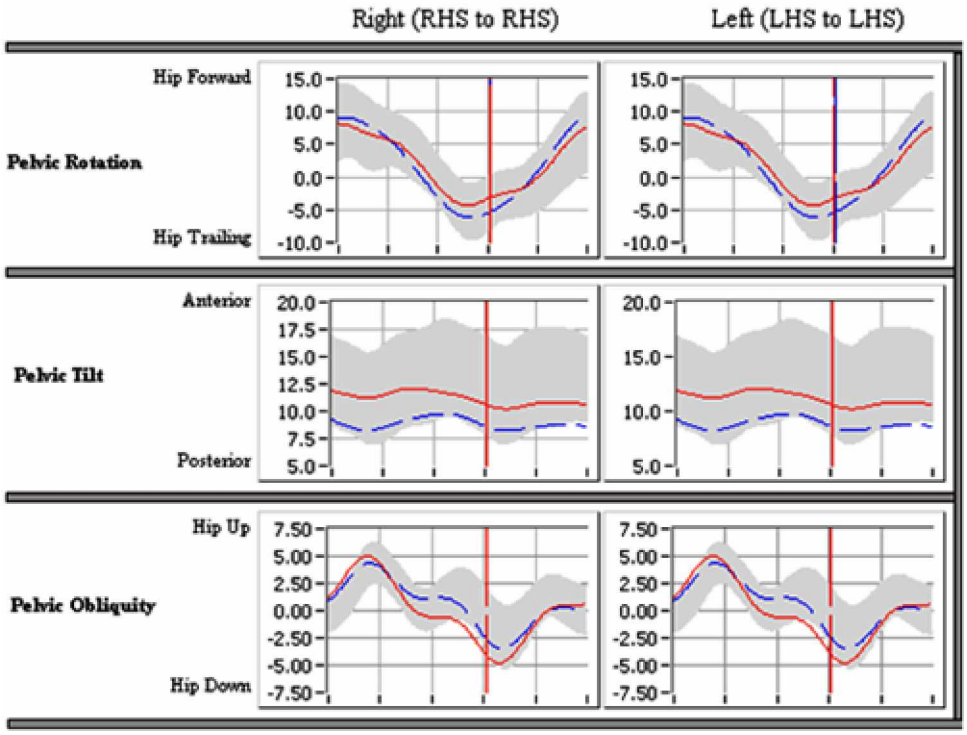

Figure B.23 Pelvis Orientation Relative to Room (Degrees), 9-year-old subjects.

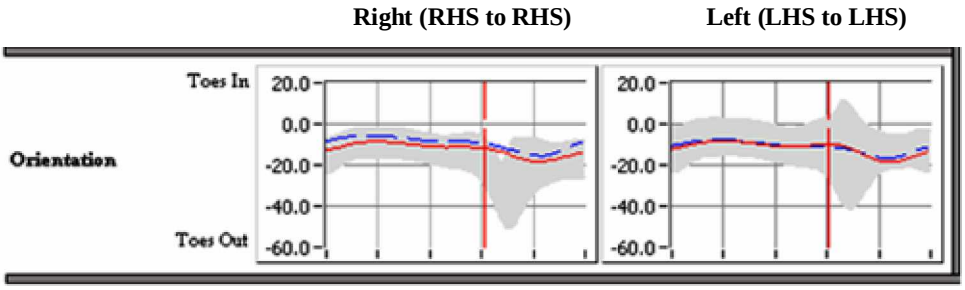

Figure B.24 Foot Orientation Relative to Room (Degrees), 9-year-old subjects.

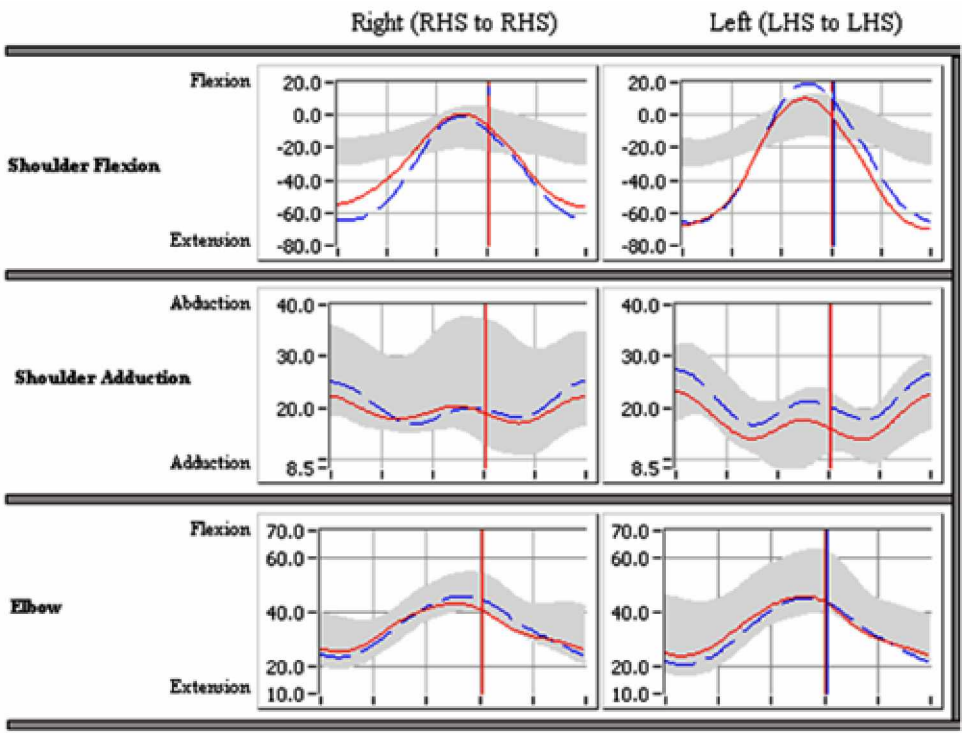

Figure B.25 Arm Joint Angles (Degrees), 9-year-old subjects.

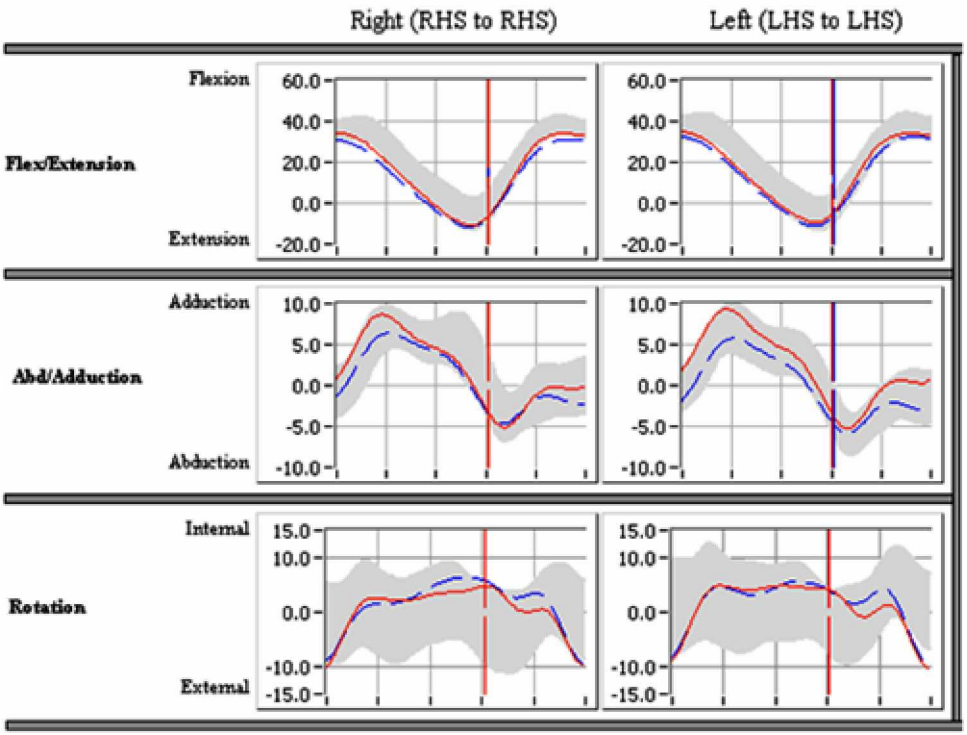

Figure B.26 Hip Joint Angles (Degrees), 9-year-old subjects.

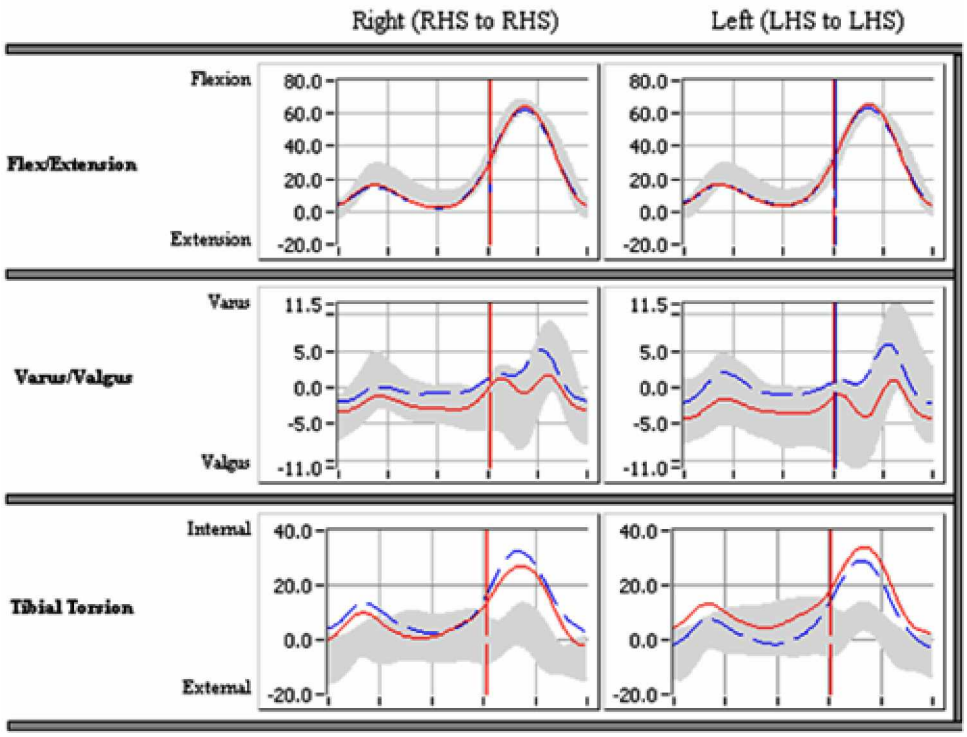

Figure B.27 Knee Joint Angles (Degrees), 9-year-old subjects.

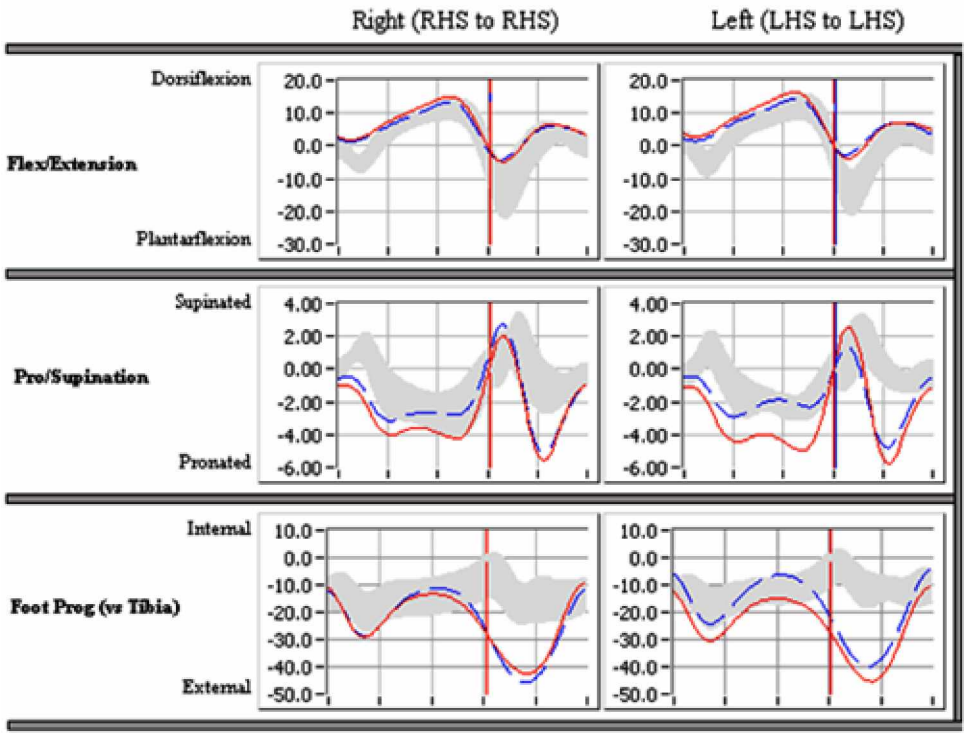

Figure B.28 Ankle Joint Angles (Degrees), 9-year-old subjects.

Sixteen-Year-Old Subjects

Table B.17 Stance Phase Kinematics of 16-year-old Female Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-11.79	7.46	5.91	11.34	54.00	13.41	-11.84	7.49	0.22	0.67
L_Hip_Rot_Ang	-6.02	9.20	13.05	11.80	37.00	19.62	-6.02	9.20	0.00	0.00
R_Hip_Abd_Ang	1.27	2.47	9.78	2.59	16.89	2.15	-2.86	2.56	47.11	26.74
L_Hip_Abd_Ang	1.70	2.40	8.24	3.12	15.89	1.83	-4.52	1.37	59.89	1.54
R_Hip_Flex_Ang	31.02	8.59	31.02	8.59	0.00	0.00	-11.68	6.35	54.33	1.94
L_Hip_Flex_Ang	29.76	8.16	29.76	8.16	0.00	0.00	-12.94	5.95	53.89	2.03
R_Knee_Rot_Ang	-0.91	12.22	10.77	11.65	32.56	25.01	-8.16	10.37	29.00	19.01
L_Knee_Rot_Ang	1.67	14.33	10.04	15.30	37.00	26.01	-5.72	13.03	36.78	19.42
R_Knee_Abd_Ang	-2.05	3.45	1.38	3.55	41.67	24.17	-3.27	3.32	27.22	27.45
L_Knee_Abd_Ang	-0.65	3.33	3.07	4.15	31.89	21.20	-1.43	3.36	19.78	26.61
R_Knee_Flex_Ang	2.91	5.04	29.71	2.74	60.78	1.56	1.71	3.96	20.22	19.63
L_Knee_Flex_Ang	1.34	4.11	25.03	2.72	59.89	1.54	-0.72	3.78	28.56	17.33
R_Ank_Rot_Ang	-5.85	8.72	-4.69	8.12	16.44	21.53	-24.14	10.17	24.00	22.14
L_Ank_Rot_Ang	-6.33	6.45	-3.84	6.42	19.89	25.28	-22.85	7.58	23.56	21.56
R_Ank_Abd_Ang	0.12	0.51	1.16	0.89	30.44	27.58	-3.00	1.53	42.56	11.01
L_Ank_Abd_Ang	0.01	0.29	0.77	0.53	24.67	26.78	-3.02	2.25	41.78	13.16
R_Ank_Flex_Ang	-0.15	2.67	14.25	2.82	45.44	4.10	-5.22	4.14	29.56	28.91
L_Ank_Flex_Ang	-0.39	2.28	13.91	2.11	45.56	1.81	-5.03	3.64	29.67	29.02
R_Elbow_Ang	26.70	3.44	42.86	6.90	51.44	3.78	25.14	3.10	7.67	3.32
L_Elbow_Ang	26.83	4.97	49.54	6.72	51.89	3.33	25.33	4.87	7.78	2.59
R_Shl_Add_Ang	22.70	4.26	22.75	4.22	5.44	14.85	13.54	3.97	48.56	16.37
L_Shl_Add_Ang	24.25	4.91	24.34	4.96	1.22	1.64	12.39	3.45	39.33	11.51
R_Shl_Flex_Ang	-66.10	17.50	-11.79	26.00	49.00	1.41	-66.58	17.37	5.00	4.39
L_Shl_Flex_Ang	-70.80	11.37	8.81	32.98	49.56	3.05	-71.32	11.06	3.33	2.69
R_Trunk_Lat_Tilt	-2.33	2.54	-0.19	1.72	50.00	20.53	-2.88	2.40	12.11	15.76
L_Trunk_Lat_Tilt	-2.33	2.54	-0.20	1.73	49.78	20.36	-2.88	2.40	12.11	15.76
R_Trunk_Fwd_Tilt	-0.45	3.09	-0.15	3.05	31.44	17.97	-2.92	3.19	44.56	24.44
L_Trunk_Fwd_Tilt	-0.45	3.09	-0.15	3.05	31.44	17.97	-2.82	3.25	43.89	23.94
R_Trunk_Rotation	-0.09	3.88	7.55	4.19	42.11	9.62	-0.22	3.85	2.78	3.70
L_Trunk_Rotation	-0.09	3.88	7.53	4.20	41.78	8.96	-0.22	3.85	2.78	3.70
R_Pelvis_Lat_Tilt	1.65	0.85	6.46	1.45	15.56	1.59	-4.67	2.47	60.78	1.56
L_Pelvis_Lat_Tilt	1.65	0.85	6.46	1.45	15.56	1.59	-4.35	2.35	59.89	1.54
R_Pelvis_Fwd_Tilt	8.59	5.60	9.14	5.77	30.22	27.60	6.90	5.80	27.11	16.39
L_Pelvis_Fwd_Tilt	8.59	5.60	9.13	5.77	30.11	27.47	6.90	5.80	27.11	16.39
R_Pelvis_Rotation	7.67	2.79	8.33	2.82	8.00	9.51	-2.86	2.29	55.00	4.03
L_Pelvis_Rotation	7.67	2.79	8.33	2.82	8.00	9.51	-2.84	2.31	54.89	3.79
R_Foot_Orientation	-10.71	4.51	-7.48	4.17	32.00	21.25	-11.52	4.39	21.89	25.67
L_Foot_Orientation	-8.06	5.69	-4.32	5.92	49.89	19.82	-8.95	5.85	24.67	23.47

Table B.18 Swing Phase Kinematics of 16-year-old Female Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Maximum Swing		**Time of Max. Sw.**		**Minimum Swing**		**Time of Min. Sw.**		**Toe Off**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	5.76	9.78	63.23	2.80	-12.29	7.12	98.68	0.93	5.23	10.62
L_Hip_Rot_Ang	12.32	11.91	65.45	6.89	-6.95	9.07	98.78	0.75	11.00	13.09
R_Hip_Abd_Ang	2.43	2.31	87.90	6.18	-4.53	2.81	72.90	13.85	-3.08	2.86
L_Hip_Abd_Ang	2.47	1.28	88.56	5.68	-6.15	1.53	65.23	1.80	-5.00	1.41
R_Hip_Flex_Ang	32.73	7.47	90.01	4.57	-6.46	5.49	61.79	1.51	-6.46	5.49
L_Hip_Flex_Ang	31.28	7.14	88.34	2.23	-8.34	5.47	61.00	1.59	-8.34	5.47
R_Knee_Rot_Ang	28.26	6.34	73.23	3.31	-3.10	10.24	89.12	16.01	6.91	12.43
L_Knee_Rot_Ang	30.36	14.45	74.23	4.00	-3.83	15.31	82.56	16.16	5.86	17.27
R_Knee_Abd_Ang	2.16	4.21	76.01	15.13	-7.58	5.36	82.90	10.33	0.38	4.20
L_Knee_Abd_Ang	4.97	4.45	76.34	12.76	-4.35	4.82	83.78	10.97	2.31	4.78
R_Knee_Flex_Ang	68.04	3.73	75.01	1.65	2.86	4.54	98.90	0.50	33.23	2.80
L_Knee_Flex_Ang	66.39	3.62	74.67	1.59	0.51	4.14	98.89	0.69	28.46	2.91
R_Ank_Rot_Ang	-5.08	8.88	98.90	0.50	-41.93	6.79	74.12	2.56	-19.91	13.49
L_Ank_Rot_Ang	-4.59	6.61	94.45	12.74	-39.42	9.77	75.78	3.81	-15.89	12.30
R_Ank_Abd_Ang	4.54	3.25	71.12	10.62	-3.32	1.61	84.01	5.98	1.11	1.41
L_Ank_Abd_Ang	4.88	3.88	71.00	10.84	-3.08	1.79	83.11	6.47	0.64	1.01
R_Ank_Flex_Ang	4.41	2.12	84.79	1.44	-8.42	6.96	69.12	11.33	-5.15	5.70
L_Ank_Flex_Ang	4.41	2.55	83.78	2.51	-10.10	7.59	69.00	11.47	-5.41	5.57
R_Elbow_Ang	38.84	6.79	63.57	6.27	26.89	3.51	99.01	0.34	38.79	6.87
L_Elbow_Ang	45.00	7.68	61.00	1.59	26.89	5.37	95.78	7.96	45.00	7.68
R_Shl_Add_Ang	22.69	4.42	98.01	1.68	13.96	4.39	64.57	3.70	14.16	4.45
L_Shl_Add_Ang	24.16	4.28	98.23	1.67	12.87	3.02	68.45	7.56	14.56	2.72
R_Shl_Flex_Ang	-24.43	23.22	61.79	1.51	-65.76	17.87	98.68	0.88	-24.43	23.22
L_Shl_Flex_Ang	-5.78	35.64	61.00	1.59	-71.21	12.28	98.45	1.82	-5.78	35.64
R_Trunk_Lat_Tilt	-0.08	1.76	70.34	10.77	-2.33	2.25	93.79	12.32	-0.39	1.62
L_Trunk_Lat_Tilt	-0.08	1.76	70.45	10.75	-2.37	2.21	93.56	13.32	-0.45	1.62
R_Trunk_Fwd_Tilt	-0.58	3.32	92.79	2.21	-3.06	3.20	63.90	1.27	-2.97	3.21
L_Trunk_Fwd_Tilt	-0.58	3.32	92.89	2.50	-3.06	3.20	63.89	1.57	-2.88	3.27
R_Trunk_Rotation	5.06	4.55	61.90	1.52	-1.10	3.73	89.90	7.84	5.06	4.55
L_Trunk_Rotation	5.16	4.63	61.45	1.25	-1.10	3.73	90.00	7.98	5.14	4.63
R_Pelvis_Lat_Tilt	1.41	1.20	93.57	5.48	-5.70	2.57	66.23	1.81	-4.98	2.50
L_Pelvis_Lat_Tilt	1.41	1.20	93.67	5.37	-5.70	2.57	66.34	1.83	-4.70	2.39
R_Pelvis_Fwd_Tilt	8.61	5.20	85.45	18.18	6.58	5.21	79.23	13.83	7.69	5.71
L_Pelvis_Fwd_Tilt	8.62	5.20	87.11	16.57	6.58	5.21	79.23	13.85	7.84	5.79
R_Pelvis_Rotation	7.76	2.37	99.01	0.34	-2.47	2.85	65.34	5.34	-2.03	2.57
L_Pelvis_Rotation	7.76	2.37	99.11	0.34	-2.59	2.64	64.89	5.93	-2.12	2.37
R_Foot_Orientation	-8.03	4.59	69.01	14.09	-16.62	5.12	83.79	7.73	-8.35	4.54
L_Foot_Orientation	-3.41	5.23	63.34	4.27	-15.36	4.33	85.11	6.47	-4.37	6.09

Table B.19 Stance Phase Kinematics of 16-year-old Male Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-11.96	3.47	3.08	4.63	59.90	1.29	-11.96	3.47	0.00	0.00
L_Hip_Rot_Ang	-11.14	8.27	1.98	8.05	53.20	7.36	-11.14	8.27	0.00	0.00
R_Hip_Abd_Ang	-1.49	3.18	3.46	2.46	16.90	1.52	-4.18	2.92	54.40	19.13
L_Hip_Abd_Ang	-2.12	1.66	2.27	1.83	17.00	2.31	-5.82	1.44	60.00	0.67
R_Hip_Flex_Ang	27.94	6.46	27.98	6.48	0.40	1.26	-9.54	6.35	53.70	1.64
L_Hip_Flex_Ang	27.15	6.23	27.16	6.23	0.30	0.95	-9.76	6.06	53.20	1.40
R_Knee_Rot_Ang	-19.36	10.96	-0.98	11.80	26.50	23.64	-22.08	12.94	10.50	17.60
L_Knee_Rot_Ang	-14.70	11.42	3.77	12.54	35.50	25.42	-16.28	10.87	17.60	23.37
R_Knee_Abd_Ang	2.49	3.85	5.46	4.56	42.80	25.29	1.62	3.54	31.10	24.56
L_Knee_Abd_Ang	2.11	2.57	4.52	1.77	39.70	24.20	0.77	2.37	26.80	28.57
R_Knee_Flex_Ang	-2.11	3.97	27.20	6.38	60.40	0.70	-2.88	4.05	18.30	20.31
L_Knee_Flex_Ang	-3.86	3.43	28.19	5.74	60.00	0.67	-4.12	3.14	8.00	16.87
R_Ank_Rot_Ang	2.07	7.75	2.59	7.95	4.00	12.65	-19.31	9.70	31.30	25.18
L_Ank_Rot_Ang	3.87	7.94	4.14	7.80	3.50	11.07	-16.46	9.48	26.40	22.98
R_Ank_Abd_Ang	-0.23	0.34	0.78	0.82	29.90	26.07	-2.25	2.28	46.30	14.02
L_Ank_Abd_Ang	-0.34	0.54	1.10	0.72	34.30	23.52	-1.93	1.71	32.50	23.75
R_Ank_Flex_Ang	0.10	3.83	12.86	3.70	46.70	1.95	-3.10	3.32	33.40	28.48
L_Ank_Flex_Ang	-1.75	2.79	12.27	2.78	47.10	1.73	-4.88	2.66	27.50	28.21
R_Elbow_Ang	30.67	10.00	50.24	4.16	52.30	4.57	29.04	9.54	9.70	2.75
L_Elbow_Ang	27.12	7.05	53.82	6.96	53.40	3.41	26.41	7.09	6.70	3.50
R_Shl_Add_Ang	25.92	3.86	26.53	3.63	11.70	23.30	16.97	5.86	29.70	5.52
L_Shl_Add_Ang	28.24	4.72	28.36	4.59	5.90	18.66	15.90	4.28	27.50	3.75
R_Shl_Flex_Ang	-63.28	10.65	-2.76	35.61	47.80	3.29	-65.18	10.21	6.90	3.03
L_Shl_Flex_Ang	-67.09	10.92	9.38	18.46	46.20	2.44	-67.94	10.72	3.90	2.13
R_Trunk_Lat_Tilt	-3.27	2.26	2.03	2.01	60.40	0.70	-5.15	2.71	14.70	1.77
L_Trunk_Lat_Tilt	-3.27	2.26	1.99	1.99	60.00	0.67	-5.15	2.71	14.70	1.77
R_Trunk_Fwd_Tilt	2.13	2.15	2.71	2.17	29.10	20.84	0.40	2.13	36.90	24.68
L_Trunk_Fwd_Tilt	2.13	2.15	2.71	2.17	29.10	20.84	0.40	2.12	36.80	24.57
R_Trunk_Rotation	-3.44	4.86	6.97	3.45	41.80	9.81	-3.53	4.85	1.50	3.24
L_Trunk_Rotation	-3.44	4.86	6.97	3.45	41.80	9.81	-3.53	4.85	1.50	3.24
R_Pelvis_Lat_Tilt	1.40	1.79	4.30	1.57	13.60	1.90	-2.12	1.47	60.30	0.67
L_Pelvis_Lat_Tilt	1.40	1.79	4.30	1.57	13.60	1.90	-1.98	1.43	59.90	0.57
R_Pelvis_Fwd_Tilt	9.94	4.32	10.53	4.43	37.10	19.84	8.14	4.51	29.50	17.09
L_Pelvis_Fwd_Tilt	9.94	4.32	10.53	4.43	37.10	19.84	8.13	4.51	29.60	17.28
R_Pelvis_Rotation	5.18	2.38	7.20	1.50	13.70	8.30	-2.45	3.15	50.70	18.11
L_Pelvis_Rotation	5.18	2.38	7.20	1.50	13.70	8.30	-2.48	3.14	50.10	17.86
R_Foot_Orientation	-23.94	5.29	-18.35	5.11	39.60	22.32	-24.10	5.25	9.10	18.79
L_Foot_Orientation	-20.14	3.39	-13.81	5.04	41.20	22.04	-20.49	3.71	6.40	16.18

Table B.20 Swing Phase Kinematics of 16-year-old Male Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Maximum Swing		**Time of Max. Sw.**		**Minimum Swing**		**Time of Min. Sw.**		**Toe Off**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	3.42	4.37	62.87	2.41	-13.87	3.84	97.47	1.04	3.10	4.53
L_Hip_Rot_Ang	2.66	7.95	67.34	8.62	-12.57	8.16	98.34	0.83	1.60	8.14
R_Hip_Abd_Ang	-1.11	2.71	91.47	6.02	-6.03	3.11	69.57	10.11	-4.46	3.01
L_Hip_Abd_Ang	-2.23	1.50	92.64	4.65	-7.75	1.43	66.14	1.37	-6.37	1.42
R_Hip_Flex_Ang	29.44	5.83	92.47	5.25	-4.11	7.35	61.27	0.80	-4.11	7.35
L_Hip_Flex_Ang	29.10	5.68	88.44	1.93	-4.20	6.88	61.04	0.53	-4.20	6.88
R_Knee_Rot_Ang	9.96	12.36	72.57	3.48	-21.59	9.89	97.87	2.51	-4.14	12.95
L_Knee_Rot_Ang	18.59	16.83	71.34	3.89	-17.47	11.04	95.84	3.19	3.12	15.19
R_Knee_Abd_Ang	7.74	3.30	76.97	13.50	0.59	3.20	90.97	10.01	5.45	4.17
L_Knee_Abd_Ang	6.98	3.07	85.24	11.35	-3.06	4.81	84.24	12.82	3.24	3.14
R_Knee_Flex_Ang	58.12	7.07	73.57	1.04	-3.67	4.41	98.57	0.53	30.64	6.52
L_Knee_Flex_Ang	61.73	4.92	73.64	0.99	-4.85	3.46	98.74	0.56	31.77	5.82
R_Ank_Rot_Ang	3.61	7.26	98.37	0.55	-30.01	10.03	72.07	2.22	-17.30	10.25
L_Ank_Rot_Ang	5.82	7.16	98.44	0.72	-30.72	11.68	73.44	3.54	-14.34	10.86
R_Ank_Abd_Ang	1.78	1.02	65.47	0.73	-3.41	2.05	79.57	0.94	0.52	0.87
L_Ank_Abd_Ang	2.86	1.80	66.34	1.46	-2.94	3.02	82.24	6.27	0.73	1.13
R_Ank_Flex_Ang	6.98	3.25	81.47	1.08	-4.57	3.00	64.37	1.08	-2.92	3.39
L_Ank_Flex_Ang	4.95	2.93	82.14	2.14	-7.38	3.91	68.14	10.86	-4.42	4.07
R_Elbow_Ang	46.91	4.42	61.27	0.80	29.89	9.51	98.87	0.18	46.91	4.42
L_Elbow_Ang	50.54	6.78	61.04	0.53	25.59	6.65	96.94	3.59	50.54	6.78
R_Shl_Add_Ang	26.94	4.02	91.57	11.47	19.86	5.49	70.67	11.49	21.75	4.08
L_Shl_Add_Ang	28.40	4.67	94.14	11.88	20.15	5.51	72.44	6.83	22.54	4.51
R_Shl_Flex_Ang	-14.83	31.80	61.97	1.74	-64.33	10.36	98.87	0.18	-14.86	31.85
L_Shl_Flex_Ang	-4.98	19.48	61.04	0.53	-66.64	11.26	99.04	0.27	-4.98	19.48
R_Trunk_Lat_Tilt	2.35	1.97	65.57	1.53	-3.06	2.20	98.87	0.18	2.13	2.00
L_Trunk_Lat_Tilt	2.35	1.97	65.74	1.54	-3.06	2.20	99.04	0.27	2.10	1.98
R_Trunk_Fwd_Tilt	2.08	2.30	92.87	3.12	0.63	2.15	65.37	5.10	0.75	2.18
L_Trunk_Fwd_Tilt	2.08	2.30	93.04	3.11	0.63	2.15	65.54	4.99	0.77	2.18
R_Trunk_Rotation	4.06	4.24	61.27	0.80	-3.91	4.53	91.47	7.04	4.06	4.24
L_Trunk_Rotation	4.17	4.15	61.04	0.53	-3.91	4.53	91.64	7.07	4.17	4.15
R_Pelvis_Lat_Tilt	1.81	1.84	86.97	1.53	-2.57	1.73	63.97	1.83	-2.29	1.54
L_Pelvis_Lat_Tilt	1.81	1.84	87.14	1.50	-2.57	1.73	64.14	1.95	-2.17	1.49
R_Pelvis_Fwd_Tilt	10.09	4.59	93.67	11.28	7.99	4.26	73.37	6.54	8.79	4.56
L_Pelvis_Fwd_Tilt	10.09	4.59	93.74	11.74	7.99	4.26	73.54	6.33	8.83	4.58
R_Pelvis_Rotation	5.49	2.91	95.17	11.65	-2.86	2.75	67.07	5.99	-2.01	3.19
L_Pelvis_Rotation	5.52	2.87	95.24	12.14	-2.87	2.72	67.14	6.06	-2.02	3.22
R_Foot_Orientation	-20.15	5.88	67.67	9.85	-28.79	6.25	90.87	6.64	-20.73	5.97
L_Foot_Orientation	-14.71	5.02	62.84	3.33	-25.85	6.43	86.24	8.77	-15.05	5.05

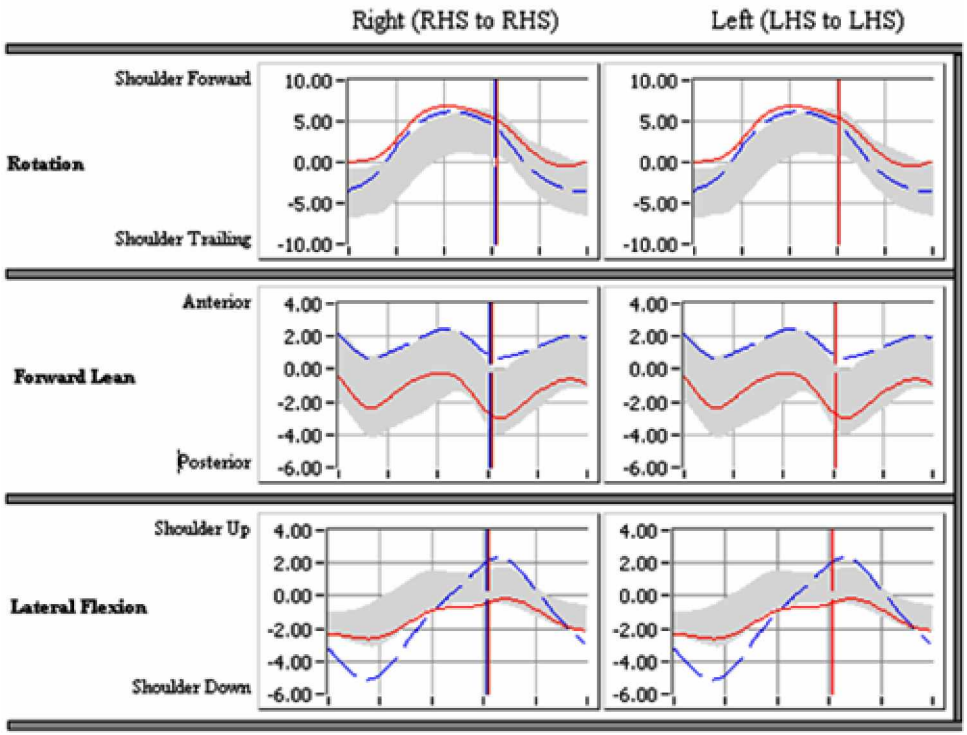

Figure B.29 Trunk Orientation Relative to Room (Degrees), 16-year-old subjects.

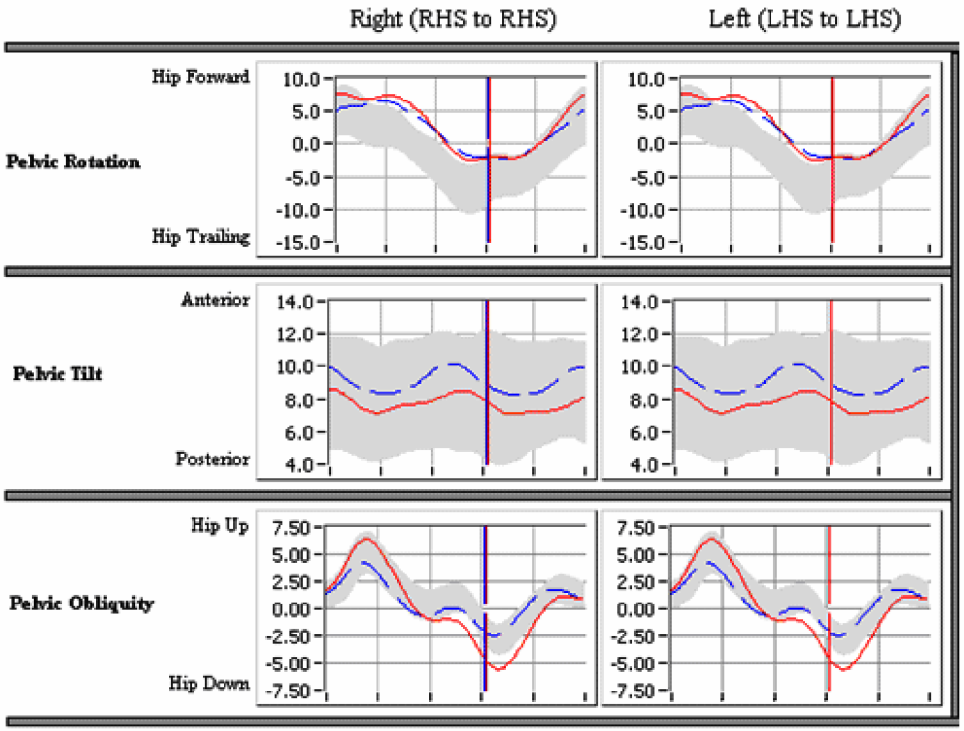

Figure B.30 Pelvis Orientation Relative to Room (Degrees), 16-year-old subjects.

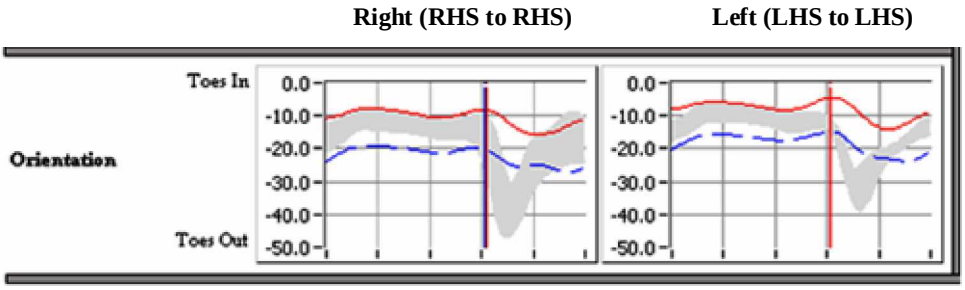

Figure B.31 Foot Orientation Relative to Room (Degrees), 16-year-old subjects.

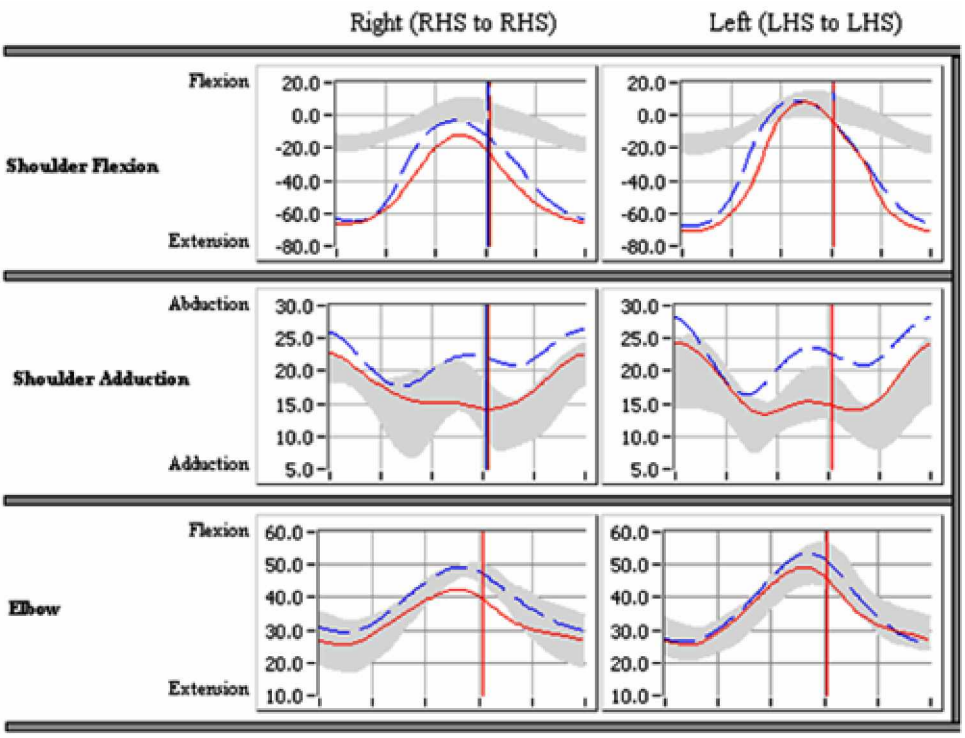

Figure B.32 Arm Joint Angles (Degrees), 16-year-old subjects.

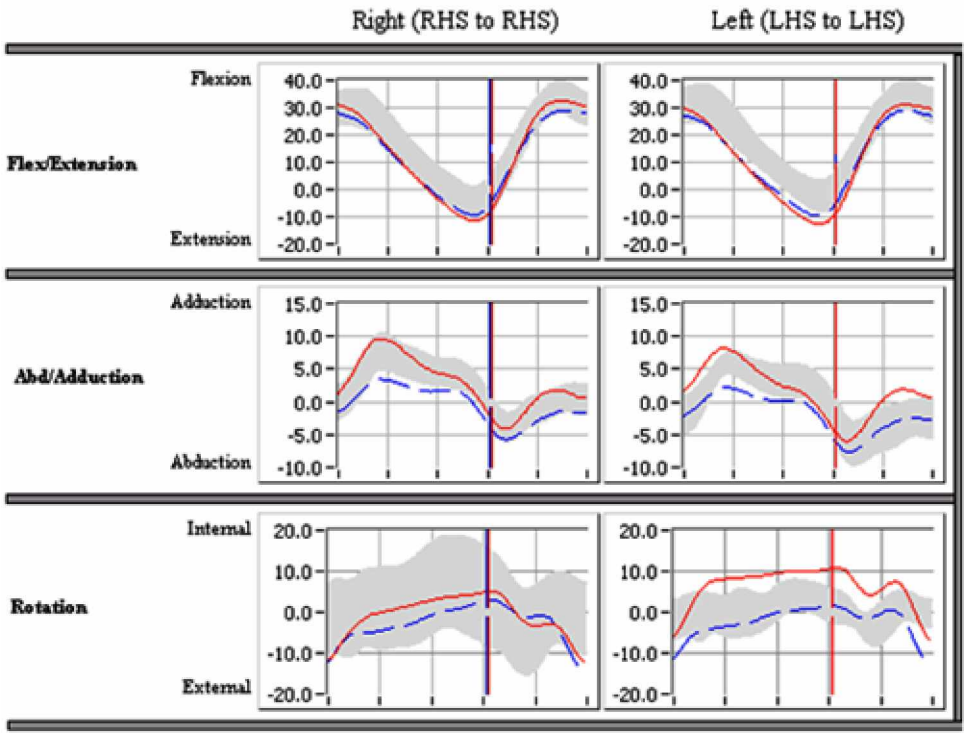

Figure B.33 Hip Joint Angles (Degrees), 16-year-old subjects.

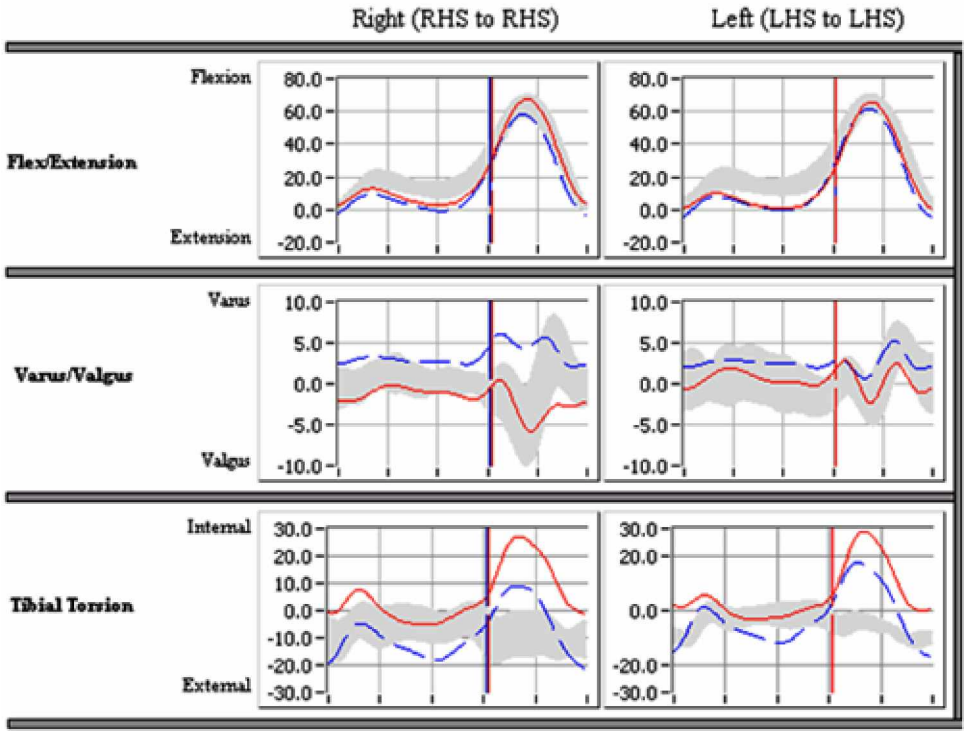

Figure B.34 Knee Joint Angles (Degrees), 16-year-old subjects.

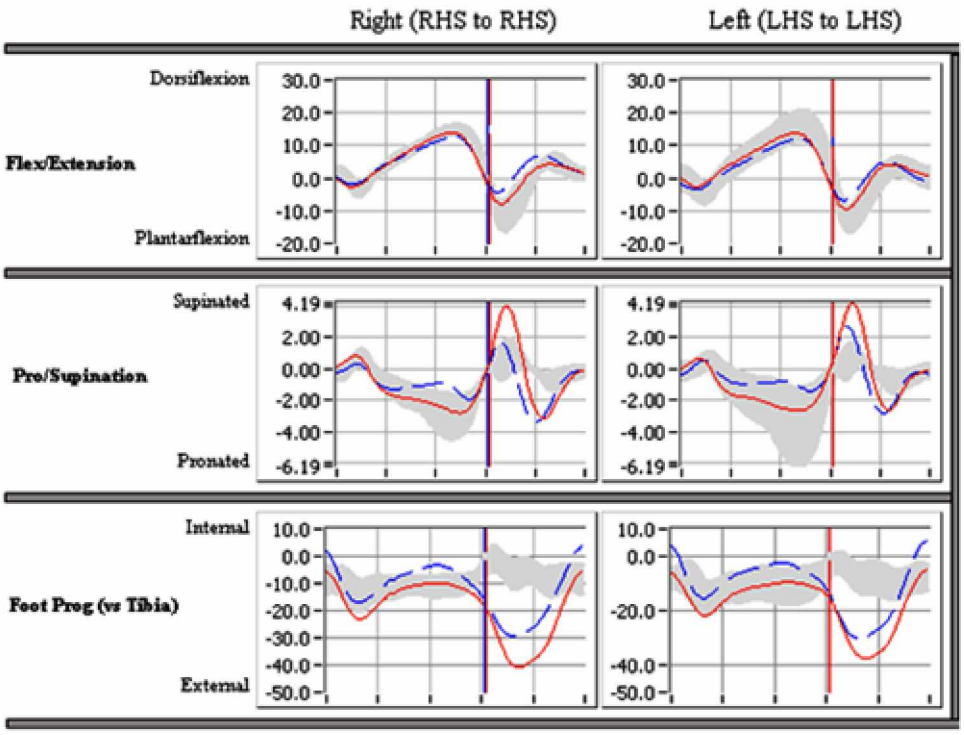

Figure B.35 Ankle Joint Angles (Degrees), 16-year-old subjects.

Seventeen-Year-Old Subjects

Table B.21 Stance Phase Kinematics of 17-year-old Female Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Foot Strike		**Maximum Stance**		**Time of Max. St.**		**Minimum Stance**		**Time of Min. St.**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-10.49	6.87	9.28	8.43	48.50	15.16	-10.54	6.84	0.50	1.58
L_Hip_Rot_Ang	-7.11	2.43	9.53	3.65	39.60	14.27	-7.11	2.43	0.00	0.00
R_Hip_Abd_Ang	1.07	4.15	9.21	4.58	15.90	0.88	-3.54	1.45	47.90	25.28
L_Hip_Abd_Ang	0.76	2.27	7.64	3.19	16.10	1.73	-4.93	2.09	59.80	1.14
R_Hip_Flex_Ang	31.39	6.53	31.39	6.53	0.00	0.00	-10.07	3.89	53.30	2.00
L_Hip_Flex_Ang	30.44	6.55	30.44	6.55	0.00	0.00	-10.59	4.63	53.50	1.72
R_Knee_Rot_Ang	-6.26	14.47	0.61	13.59	31.70	26.79	-16.80	10.37	32.70	4.45
L_Knee_Rot_Ang	-4.04	14.31	2.22	11.72	38.90	27.59	-15.51	11.21	39.30	12.26
R_Knee_Abd_Ang	-2.88	3.87	1.34	3.34	44.60	20.08	-3.61	3.75	37.10	24.82
L_Knee_Abd_Ang	-1.78	3.35	2.22	3.78	37.30	20.56	-2.77	3.06	37.00	26.50
R_Knee_Flex_Ang	0.64	6.03	25.49	4.50	59.70	1.42	-2.49	4.64	26.60	14.87
L_Knee_Flex_Ang	-0.21	5.39	23.97	4.82	59.80	1.14	-3.79	4.78	33.30	6.20
R_Ank_Rot_Ang	-3.29	7.64	-0.84	5.66	27.80	25.63	-17.53	6.24	41.00	24.56
L_Ank_Rot_Ang	-1.74	8.79	1.13	5.98	21.00	26.54	-12.74	6.61	34.60	23.97
R_Ank_Abd_Ang	-0.23	0.57	1.30	0.84	38.50	26.94	-1.74	1.05	44.80	10.69
L_Ank_Abd_Ang	-0.35	0.33	0.96	0.46	35.50	25.86	-1.50	0.68	42.60	17.77
R_Ank_Flex_Ang	-3.63	5.79	10.86	2.42	45.90	1.85	-8.32	3.51	37.50	28.43
L_Ank_Flex_Ang	-3.48	3.96	10.84	2.70	45.80	1.99	-8.73	2.77	38.10	27.87
R_Elbow_Ang	28.58	6.96	45.49	6.13	49.70	5.56	26.54	6.12	9.40	3.47
L_Elbow_Ang	21.30	6.41	48.35	8.30	52.60	3.75	19.49	6.05	8.10	2.69
R_Shl_Add_Ang	24.03	2.73	24.04	2.73	0.50	0.71	14.62	1.98	49.90	11.63
L_Shl_Add_Ang	26.09	3.52	26.17	3.53	1.10	1.45	13.37	3.10	35.90	11.45
R_Shl_Flex_Ang	-69.28	12.80	-13.14	26.73	50.30	2.58	-70.33	12.28	4.90	2.88
L_Shl_Flex_Ang	-74.13	12.08	16.63	21.14	50.60	2.12	-75.45	10.90	5.50	3.06
R_Trunk_Lat_Tilt	-3.63	2.61	-1.01	2.74	54.20	9.00	-4.29	2.45	11.10	7.89
L_Trunk_Lat_Tilt	-3.63	2.61	-1.00	2.76	54.40	9.08	-4.29	2.45	11.10	7.89
R_Trunk_Fwd_Tilt	-0.68	3.09	0.11	2.74	30.10	16.40	-3.03	2.74	50.20	20.44
L_Trunk_Fwd_Tilt	-0.68	3.09	0.11	2.74	30.10	16.40	-3.02	2.74	45.60	23.66
R_Trunk_Rotation	-1.35	2.63	9.28	2.68	43.80	4.73	-1.36	2.63	0.30	0.95
L_Trunk_Rotation	-1.35	2.63	9.28	2.68	43.80	4.73	-1.36	2.63	0.30	0.95
R_Pelvis_Lat_Tilt	1.31	1.49	6.87	2.45	14.90	1.10	-4.40	1.03	59.70	1.42
L_Pelvis_Lat_Tilt	1.31	1.49	6.87	2.45	14.90	1.10	-4.50	0.88	59.80	1.14
R_Pelvis_Fwd_Tilt	10.69	3.73	11.55	3.76	25.30	19.74	9.11	3.31	30.30	18.65
L_Pelvis_Fwd_Tilt	10.69	3.73	11.55	3.76	25.30	19.74	9.11	3.31	30.30	18.65
R_Pelvis_Rotation	6.92	3.88	8.33	3.64	14.60	11.33	-2.76	3.88	55.50	3.24
L_Pelvis_Rotation	6.92	3.88	8.33	3.64	14.60	11.33	-2.78	3.86	55.60	3.41
R_Foot_Orientation	-12.78	6.98	-9.37	7.35	23.40	18.26	-13.85	6.98	35.00	25.17
L_Foot_Orientation	-10.82	6.96	-7.47	6.79	46.50	20.84	-11.81	6.73	26.50	22.95

Table B.22 Swing Phase Kinematics of 17-year-old Female Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Maximum Swing		**Time of Max. Sw.**		**Minimum Swing**		**Time of Min. Sw.**		**Toe Off**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	8.43	9.31	63.81	3.00	-10.93	7.47	98.61	0.90	7.64	8.92
L_Hip_Rot_Ang	9.06	4.63	67.13	9.21	-8.37	2.51	98.43	0.69	7.79	4.62
R_Hip_Abd_Ang	2.27	4.00	89.51	6.41	-5.87	1.61	66.11	1.72	-3.94	1.51
L_Hip_Abd_Ang	2.17	1.17	88.53	4.41	-7.12	1.80	65.53	1.12	-5.58	2.06
R_Hip_Flex_Ang	33.62	6.65	89.61	4.78	-5.15	3.81	60.71	1.35	-5.15	3.81
L_Hip_Flex_Ang	32.94	6.34	89.93	3.91	-5.86	4.11	60.73	1.16	-5.86	4.11
R_Knee_Rot_Ang	15.12	13.84	74.41	8.48	-12.72	11.49	87.11	14.78	-4.62	13.18
L_Knee_Rot_Ang	16.36	13.69	74.33	8.94	-12.62	14.11	81.33	15.78	-2.10	13.94
R_Knee_Abd_Ang	3.86	4.91	72.51	11.63	-5.63	4.82	88.71	9.23	1.23	3.83
L_Knee_Abd_Ang	3.79	5.55	78.63	15.95	-5.29	2.99	84.23	11.34	0.84	4.50
R_Knee_Flex_Ang	61.20	6.85	74.11	1.26	-0.15	5.35	98.51	1.32	28.69	4.70
L_Knee_Flex_Ang	61.49	6.12	74.13	1.10	-0.82	4.56	98.63	1.12	27.24	4.95
R_Ank_Rot_Ang	-1.63	7.61	94.31	12.59	-34.10	9.51	73.71	4.20	-13.11	7.92
L_Ank_Rot_Ang	0.25	8.44	90.53	16.18	-29.33	7.99	72.63	2.21	-8.60	6.09
R_Ank_Abd_Ang	4.35	1.72	66.81	0.86	-2.15	1.55	85.71	7.12	1.69	1.05
L_Ank_Abd_Ang	5.16	1.65	67.83	0.84	-1.39	1.38	88.83	8.66	1.27	0.70
R_Ank_Flex_Ang	3.86	2.54	83.81	1.26	-10.22	2.82	63.91	1.31	-7.74	2.08
L_Ank_Flex_Ang	2.33	3.49	85.33	2.27	-13.81	3.86	64.63	1.28	-9.53	2.85
R_Elbow_Ang	42.41	6.28	60.71	1.35	27.44	7.31	99.01	0.20	42.41	6.28
L_Elbow_Ang	44.87	8.36	60.93	1.09	19.70	6.95	98.93	0.35	44.83	8.27
R_Shl_Add_Ang	23.92	2.88	95.31	11.23	14.30	2.99	68.71	10.55	15.29	2.40
L_Shl_Add_Ang	26.08	3.19	98.63	1.08	13.35	3.75	69.03	6.62	15.63	3.47
R_Shl_Flex_Ang	-21.72	27.53	61.61	3.22	-68.34	13.97	98.11	2.86	-21.84	27.57
L_Shl_Flex_Ang	3.65	26.17	60.73	1.16	-75.64	11.93	98.93	0.35	3.65	26.17
R_Trunk_Lat_Tilt	-1.03	2.78	67.01	5.01	-3.49	2.69	98.01	2.17	-1.24	2.72
L_Trunk_Lat_Tilt	-1.03	2.78	66.93	4.84	-3.49	2.69	97.93	2.07	-1.22	2.74
R_Trunk_Fwd_Tilt	-0.85	3.09	88.71	6.05	-3.08	2.77	62.61	1.32	-3.00	2.83
L_Trunk_Fwd_Tilt	-0.85	3.09	88.63	6.19	-3.08	2.77	62.53	1.49	-2.98	2.82
R_Trunk_Rotation	6.49	3.21	60.71	1.35	-2.13	2.56	94.11	4.94	6.49	3.21
L_Trunk_Rotation	6.49	3.27	60.73	1.16	-2.13	2.56	94.03	5.08	6.49	3.27
R_Pelvis_Lat_Tilt	0.94	1.42	93.91	4.48	-5.91	0.96	65.61	1.24	-4.80	0.99
L_Pelvis_Lat_Tilt	0.94	1.42	93.83	4.58	-5.91	0.96	65.53	1.11	-4.90	0.88
R_Pelvis_Fwd_Tilt	10.79	3.77	79.71	12.31	9.38	3.49	79.51	16.67	9.94	3.32
L_Pelvis_Fwd_Tilt	10.79	3.77	81.23	10.55	9.38	3.49	79.43	16.63	10.00	3.34
R_Pelvis_Rotation	6.12	3.48	99.01	0.20	-2.89	3.27	70.11	5.84	-2.02	3.45
L_Pelvis_Rotation	6.12	3.48	98.93	0.35	-2.88	3.27	70.13	5.85	-2.00	3.44
R_Foot_Orientation	-10.77	8.93	73.01	18.05	-23.66	7.69	81.61	6.37	-11.55	8.59
L_Foot_Orientation	-7.36	7.37	61.93	2.42	-21.03	8.21	82.73	3.63	-7.69	6.98

Table B.23 Stance Phase Kinematics of 17-year-old Male Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Foot Strike		**Maximum Stance**		**Time of Max. St.**		**Minimum Stance**		**Time of Min. St.**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-16.22	6.46	-4.22	5.64	58.70	5.33	-16.22	6.46	0.00	0.00
L_Hip_Rot_Ang	-12.57	8.25	-0.61	7.47	47.30	15.90	-12.95	7.89	3.50	11.07
R_Hip_Abd_Ang	-0.80	3.00	4.79	2.68	21.30	10.95	-3.36	3.17	54.60	19.23
L_Hip_Abd_Ang	-2.56	2.10	3.22	2.39	28.40	14.98	-5.40	2.30	48.10	25.38
R_Hip_Flex_Ang	30.25	8.83	30.40	8.97	0.50	1.58	-8.84	6.35	53.50	1.72
L_Hip_Flex_Ang	30.19	9.51	30.27	9.59	0.60	1.35	-9.02	6.93	53.30	1.49
R_Knee_Rot_Ang	-9.70	12.85	6.83	10.85	17.30	15.09	-12.36	13.00	23.40	20.04
L_Knee_Rot_Ang	-7.74	13.50	8.82	14.16	26.90	23.36	-11.79	13.12	25.40	22.65
R_Knee_Abd_Ang	-0.81	2.88	1.51	3.35	53.30	9.23	-1.93	3.05	35.20	27.26
L_Knee_Abd_Ang	-0.17	2.50	3.09	3.32	52.80	13.51	-1.07	2.44	25.80	24.40
R_Knee_Flex_Ang	-2.22	4.54	27.49	5.61	60.50	1.43	-4.12	3.21	23.90	20.71
L_Knee_Flex_Ang	-2.25	5.61	27.82	5.55	60.20	1.40	-4.26	4.49	23.90	20.68
R_Ank_Rot_Ang	-0.88	9.30	0.54	8.44	19.00	20.13	-19.73	7.77	12.20	1.99
L_Ank_Rot_Ang	-0.95	7.62	1.35	6.23	16.30	21.13	-19.69	8.64	17.20	15.16
R_Ank_Abd_Ang	-0.15	0.39	1.56	0.69	31.10	24.75	-1.88	1.79	39.00	15.19
L_Ank_Abd_Ang	-0.23	0.44	1.35	0.79	32.40	26.85	-2.19	1.63	29.60	23.67
R_Ank_Flex_Ang	-2.51	3.23	10.79	3.52	47.20	2.49	-6.82	4.19	38.90	28.12
L_Ank_Flex_Ang	-2.18	2.94	11.27	3.46	47.60	2.12	-6.90	4.46	43.90	26.19
R_Elbow_Ang	30.61	6.22	50.75	9.43	50.10	2.81	28.66	5.81	9.10	4.93
L_Elbow_Ang	24.53	5.21	54.22	11.85	53.20	5.18	23.13	4.84	8.20	3.82
R_Shl_Add_Ang	25.90	5.51	26.21	5.27	12.80	25.96	17.51	3.56	31.10	6.31
L_Shl_Add_Ang	26.21	5.85	26.66	5.44	21.60	27.61	15.91	3.04	26.90	5.17
R_Shl_Flex_Ang	-54.42	12.75	-13.21	6.93	47.90	1.73	-57.03	11.76	6.90	4.53
L_Shl_Flex_Ang	-59.45	11.28	9.77	22.93	47.10	2.18	-61.00	11.49	5.50	3.03
R_Trunk_Lat_Tilt	-2.91	1.98	2.42	1.70	60.50	1.43	-4.75	1.84	14.70	2.41
L_Trunk_Lat_Tilt	-2.91	1.98	2.39	1.67	60.20	1.40	-4.75	1.84	14.70	2.41
R_Trunk_Fwd_Tilt	1.93	2.43	2.63	2.33	27.20	18.95	0.20	2.53	40.20	26.31
L_Trunk_Fwd_Tilt	1.93	2.43	2.63	2.33	27.20	18.95	0.22	2.51	39.90	26.05
R_Trunk_Rotation	-2.69	3.68	7.78	4.01	41.70	7.15	-2.85	3.57	2.70	4.45
L_Trunk_Rotation	-2.69	3.68	7.78	4.01	41.70	7.15	-2.85	3.57	2.70	4.45
R_Pelvis_Lat_Tilt	0.93	1.77	3.88	1.48	13.70	0.95	-1.81	2.16	57.60	9.45
L_Pelvis_Lat_Tilt	0.93	1.77	3.88	1.48	13.70	0.95	-1.75	2.12	57.30	9.35
R_Pelvis_Fwd_Tilt	10.84	4.81	11.40	4.92	26.50	23.04	9.06	4.93	31.50	24.64
L_Pelvis_Fwd_Tilt	10.84	4.81	11.40	4.92	26.50	23.04	9.06	4.93	31.40	24.52
R_Pelvis_Rotation	5.97	3.10	6.97	2.81	9.50	8.38	-3.12	2.99	56.90	3.54
L_Pelvis_Rotation	5.97	3.10	6.97	2.81	9.50	8.38	-3.12	3.00	56.10	3.25
R_Foot_Orientation	-20.95	5.67	-15.66	5.06	23.40	18.48	-21.15	5.66	9.40	19.84
L_Foot_Orientation	-19.16	5.23	-13.81	5.16	41.40	23.70	-19.73	4.74	9.90	20.90

Table B.24 Swing Phase Kinematics of 17-year-old Male Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Maximum Swing		**Time of Max. Sw.**		**Minimum Swing**		**Time of Min. Sw.**		**Toe Off**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-2.66	5.59	66.38	6.83	-18.43	6.57	97.58	1.34	-4.09	5.67
L_Hip_Rot_Ang	-0.12	7.62	68.85	8.79	-14.02	7.93	98.25	0.88	-1.39	7.60
R_Hip_Abd_Ang	0.30	2.88	90.08	4.61	-5.48	3.15	66.68	1.78	-3.89	3.19
L_Hip_Abd_Ang	-1.90	2.21	87.95	11.05	-7.53	2.94	66.55	1.66	-5.72	2.68
R_Hip_Flex_Ang	31.03	7.70	90.78	5.28	-2.91	7.06	61.38	1.33	-2.91	7.06
L_Hip_Flex_Ang	30.92	7.71	90.85	5.48	-3.37	7.32	61.15	1.28	-3.37	7.32
R_Knee_Rot_Ang	14.66	12.52	71.08	1.85	-13.86	12.26	94.78	3.52	1.48	10.95
L_Knee_Rot_Ang	20.46	10.84	72.15	3.54	-12.35	11.96	94.35	3.06	4.77	12.09
R_Knee_Abd_Ang	3.02	4.51	78.28	13.16	-3.79	3.99	82.28	11.63	0.46	4.31
L_Knee_Abd_Ang	5.17	5.16	78.35	11.53	-2.28	3.11	85.35	12.68	2.77	4.26
R_Knee_Flex_Ang	58.18	5.80	73.38	1.30	-4.60	3.80	98.28	0.84	30.90	5.71
L_Knee_Flex_Ang	59.97	2.87	73.35	1.00	-4.41	4.64	98.35	0.59	31.29	5.41
R_Ank_Rot_Ang	1.27	9.30	97.98	0.99	-29.99	7.61	72.18	2.43	-14.07	8.28
L_Ank_Rot_Ang	1.45	6.44	97.85	1.21	-31.83	5.99	73.25	3.38	-13.79	9.13
R_Ank_Abd_Ang	4.16	2.86	66.88	1.67	-1.59	1.43	81.08	2.27	1.64	1.20
L_Ank_Abd_Ang	4.71	2.82	67.15	1.56	-1.54	1.22	86.05	8.92	1.31	1.59
R_Ank_Flex_Ang	3.56	2.58	83.78	4.65	-9.49	6.13	64.88	1.45	-6.84	5.63
L_Ank_Flex_Ang	3.13	2.99	84.55	5.88	-11.39	6.48	68.55	10.77	-7.35	6.26
R_Elbow_Ang	46.23	9.21	61.38	1.33	29.53	6.89	98.48	1.38	46.23	9.21
L_Elbow_Ang	50.07	12.61	61.15	1.28	23.89	5.73	95.05	7.23	50.07	12.61
R_Shl_Add_Ang	25.84	4.37	88.78	14.35	20.75	3.74	71.08	12.62	21.44	3.93
L_Shl_Add_Ang	26.00	5.22	88.45	15.17	20.17	3.63	72.55	6.17	21.44	3.95
R_Shl_Flex_Ang	-23.09	7.18	61.38	1.33	-54.63	13.13	98.38	1.07	-23.09	7.18
L_Shl_Flex_Ang	-6.47	18.63	61.15	1.28	-59.73	11.33	98.95	0.23	-6.47	18.63
R_Trunk_Lat_Tilt	2.77	1.62	65.38	2.23	-2.72	1.96	98.88	0.31	2.53	1.68
L_Trunk_Lat_Tilt	2.77	1.62	65.45	2.12	-2.72	1.96	98.95	0.23	2.50	1.66
R_Trunk_Fwd_Tilt	1.81	2.35	85.98	8.30	0.33	2.62	69.58	15.62	0.39	2.62
L_Trunk_Fwd_Tilt	1.81	2.35	86.05	8.43	0.33	2.62	69.65	15.42	0.40	2.60
R_Trunk_Rotation	5.39	4.01	61.38	1.33	-3.18	3.44	90.08	7.49	5.39	4.01
L_Trunk_Rotation	5.47	4.03	61.15	1.28	-3.18	3.44	90.15	7.52	5.47	4.03
R_Pelvis_Lat_Tilt	2.05	1.72	86.08	1.97	-2.27	2.23	67.48	11.16	-1.98	2.20
L_Pelvis_Lat_Tilt	2.05	1.72	86.15	2.11	-2.28	2.22	67.45	11.15	-1.94	2.16
R_Pelvis_Fwd_Tilt	10.88	5.01	93.48	6.49	9.28	4.92	70.78	11.70	9.54	4.95
L_Pelvis_Fwd_Tilt	10.88	5.01	93.55	6.52	9.27	4.92	70.75	11.75	9.54	4.96
R_Pelvis_Rotation	5.89	3.53	98.88	0.31	-3.28	2.62	67.48	5.23	-2.63	2.65
L_Pelvis_Rotation	5.89	3.53	98.95	0.23	-3.30	2.64	67.45	5.27	-2.63	2.67
R_Foot_Orientation	-17.50	6.28	65.48	6.25	-27.60	7.41	89.28	7.48	-18.36	5.60
L_Foot_Orientation	-14.36	5.74	63.15	3.74	-26.05	6.75	88.35	5.52	-14.99	5.17

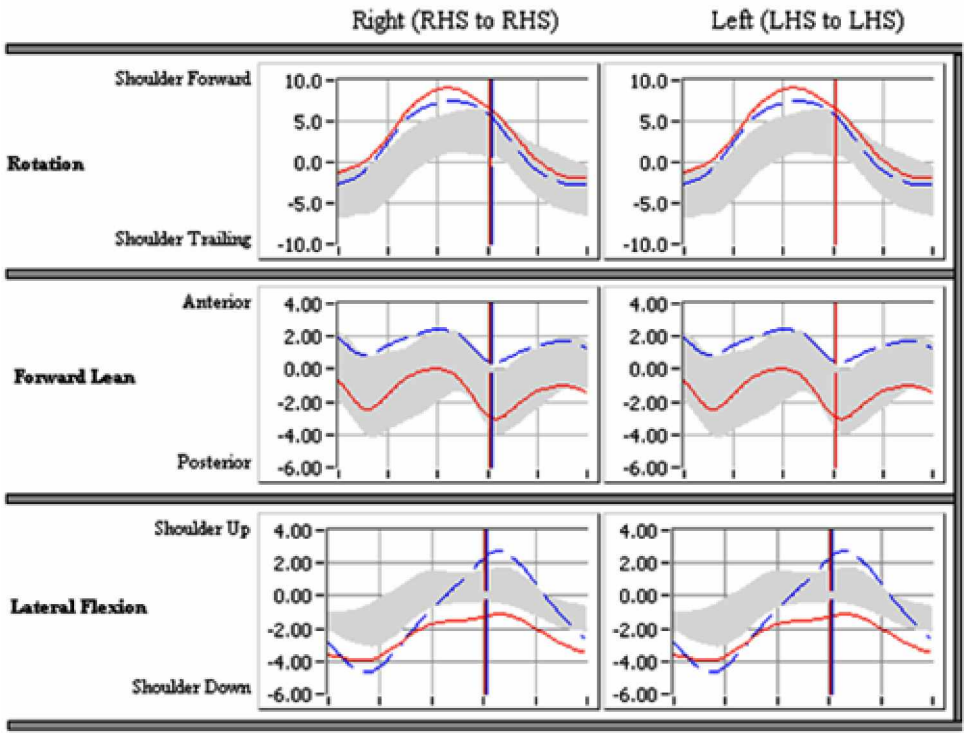

Figure B.36 Trunk Orientation Relative to Room (Degrees), 17-year-old subjects.

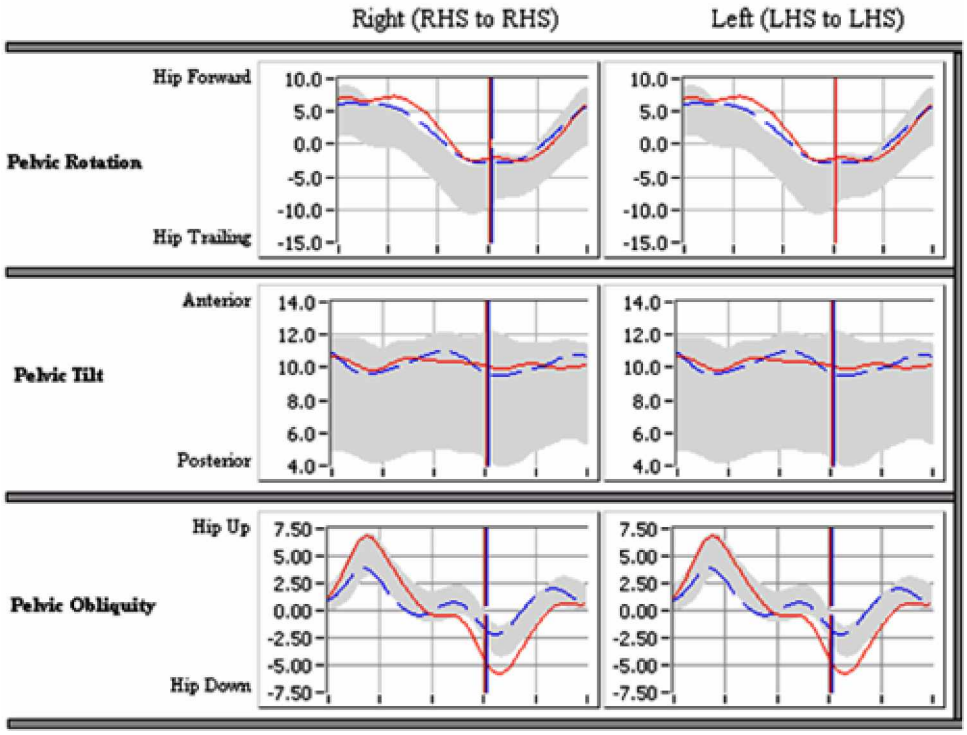

Figure B.37 Pelvis Orientation Relative to Room (Degrees), 17-year-old subjects.

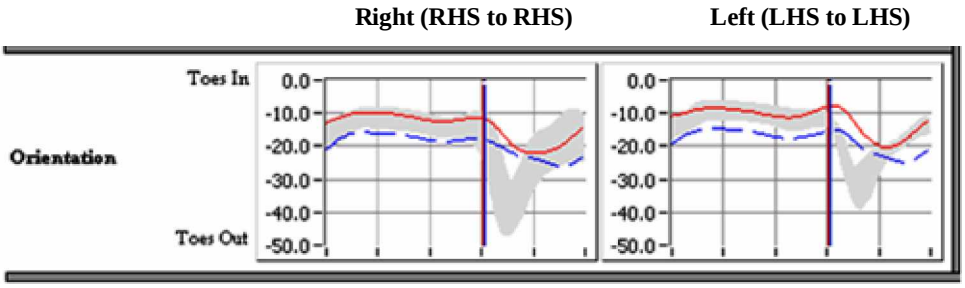

Figure B.38 Foot Orientation Relative to Room (Degrees), 17-year-old subjects.

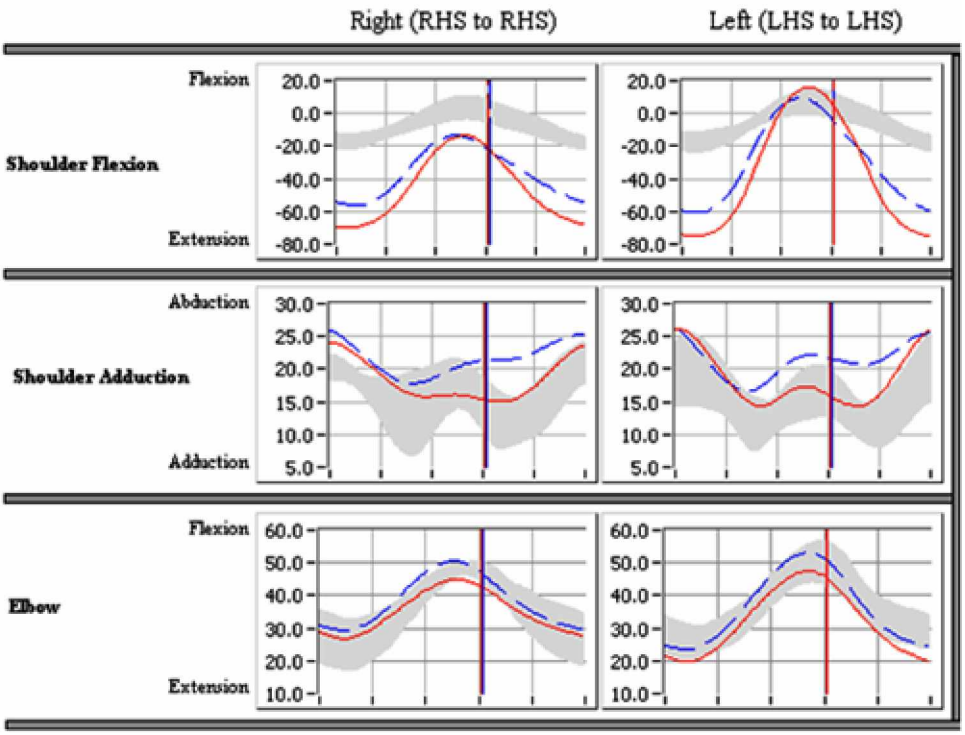

Figure B.39 Arm Joint Angles (Degrees), 17-year-old subjects.

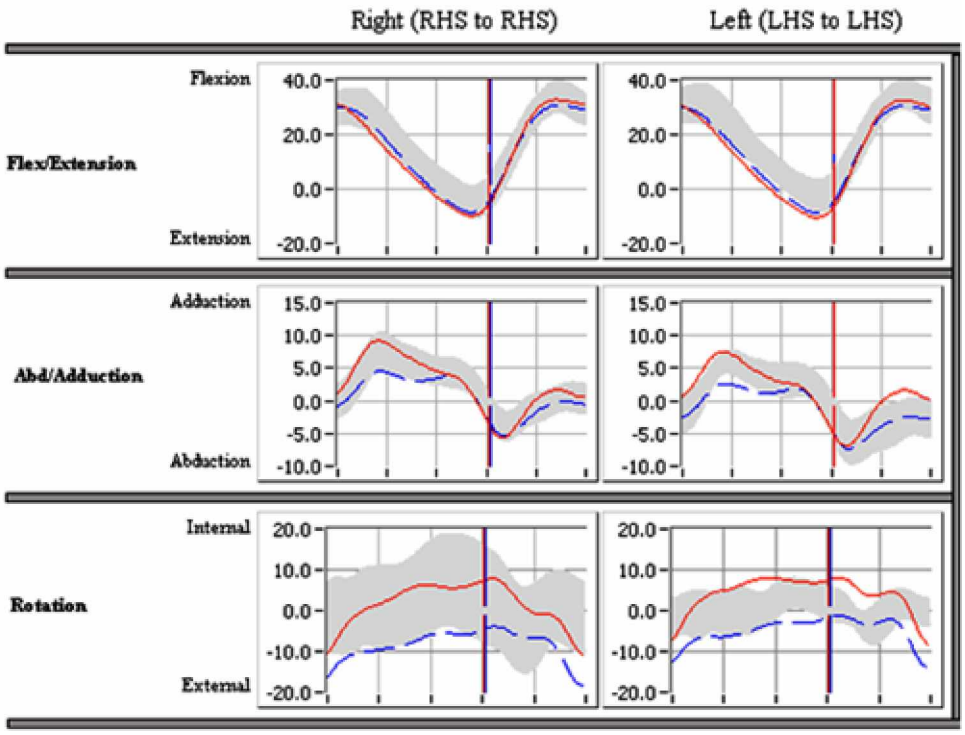

Figure B.40 Hip Joint Angles (Degrees), 17-year-old subjects.

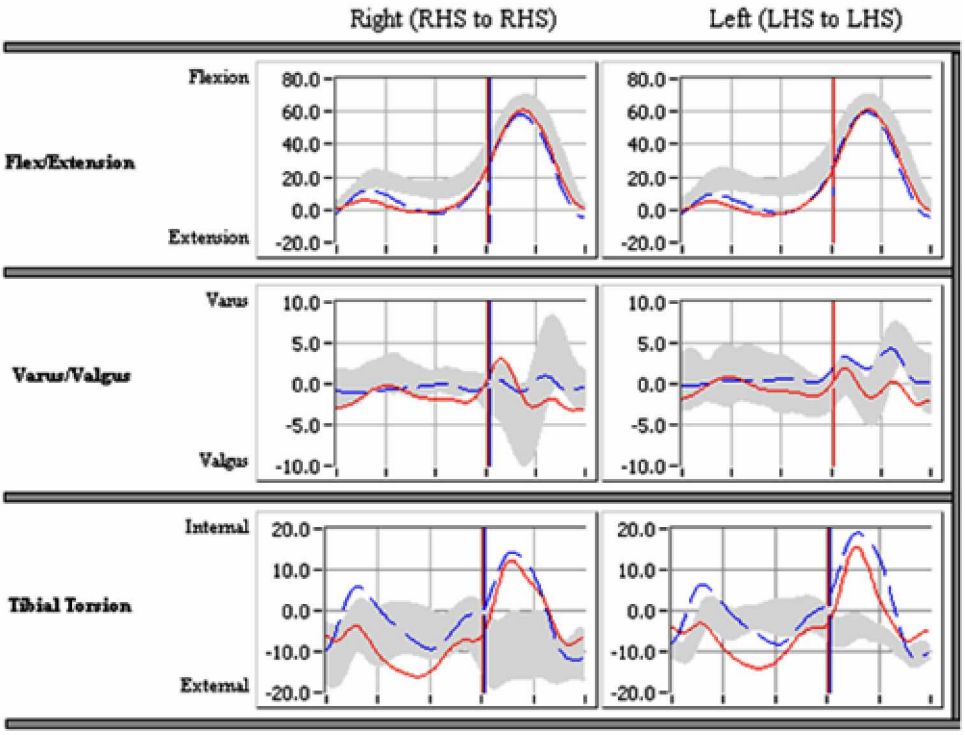

Figure B.41 Knee Joint Angles (Degrees), 17-year-old subjects.

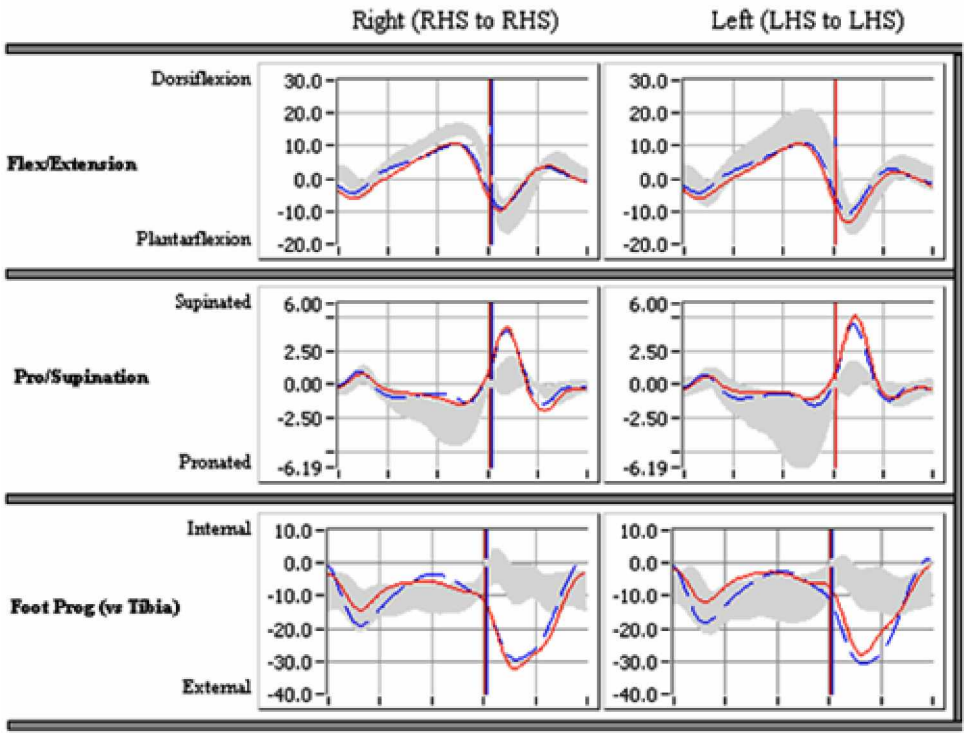

Figure B.42 Ankle Joint Angles (Degrees), 17-year-old subjects.

Eighteen-Year-Old Subjects

Table B.25 Stance Phase Kinematics of 18-year-old Female Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-7.37	5.54	11.60	7.65	45.90	13.28	-7.37	5.54	0.00	0.00
L_Hip_Rot_Ang	-9.98	4.96	7.82	5.59	42.00	13.09	-9.98	4.96	0.00	0.00
R_Hip_Abd_Ang	1.97	4.69	10.26	4.47	15.70	0.82	-3.88	2.71	53.80	18.93
L_Hip_Abd_Ang	0.12	1.97	8.44	2.90	16.10	1.37	-4.40	2.71	53.20	18.72
R_Hip_Flex_Ang	33.54	6.68	33.54	6.68	0.00	0.00	-9.66	4.37	53.90	1.45
L_Hip_Flex_Ang	33.16	6.53	33.16	6.53	0.00	0.00	-8.95	5.63	53.80	1.48
R_Knee_Rot_Ang	-9.21	14.61	-3.81	13.97	28.50	24.33	-19.30	11.88	36.60	8.85
L_Knee_Rot_Ang	-8.73	12.17	-1.71	10.25	32.40	29.25	-20.26	9.53	36.50	11.18
R_Knee_Abd_Ang	-1.98	3.49	2.77	2.48	39.80	21.11	-2.49	3.33	27.30	28.60
L_Knee_Abd_Ang	-1.51	2.75	2.07	2.02	32.40	20.00	-2.16	2.58	33.20	28.27
R_Knee_Flex_Ang	1.39	5.00	24.84	3.84	59.70	0.95	-1.47	4.02	31.60	12.38
L_Knee_Flex_Ang	1.09	4.45	24.92	4.49	59.20	1.03	-2.15	3.63	32.10	5.97
R_Ank_Rot_Ang	-2.14	7.87	0.62	6.38	31.10	27.18	-14.96	5.93	21.50	20.03
L_Ank_Rot_Ang	0.96	7.47	2.53	5.17	19.60	25.40	-11.59	5.52	25.60	21.99
R_Ank_Abd_Ang	-0.25	0.52	1.15	0.76	36.20	25.13	-1.31	0.73	33.60	17.34
L_Ank_Abd_Ang	-0.41	0.25	1.04	0.39	36.20	23.48	-1.16	0.63	30.00	23.07
R_Ank_Flex_Ang	-2.31	5.02	11.20	1.91	45.40	1.26	-7.82	3.17	43.80	26.14
L_Ank_Flex_Ang	-2.51	4.13	11.14	2.14	45.40	1.07	-8.25	1.60	43.40	25.60
R_Elbow_Ang	24.42	8.61	47.07	9.78	50.30	5.38	22.95	7.71	8.20	3.46
L_Elbow_Ang	19.87	5.90	49.66	12.94	52.50	3.95	18.48	5.70	6.90	3.73
R_Shl_Add_Ang	23.73	3.26	23.95	3.40	5.70	16.63	12.97	2.86	42.00	12.19
L_Shl_Add_Ang	25.85	3.58	26.17	3.94	6.40	16.13	10.85	3.53	32.70	9.04
R_Shl_Flex_Ang	-72.95	12.51	1.71	32.97	48.50	6.84	-73.54	12.26	3.30	3.23
L_Shl_Flex_Ang	-78.17	10.68	36.82	25.79	50.90	3.07	-79.53	9.32	6.10	3.63
R_Trunk_Lat_Tilt	-2.16	3.59	0.10	2.68	45.80	18.80	-2.89	3.10	18.40	21.00
L_Trunk_Lat_Tilt	-2.16	3.59	0.07	2.67	45.70	18.73	-2.88	3.10	18.20	20.57
R_Trunk_Fwd_Tilt	-1.40	3.19	-0.70	3.08	25.60	18.29	-3.99	3.21	40.60	24.84
L_Trunk_Fwd_Tilt	-1.40	3.19	-0.70	3.08	25.60	18.29	-3.93	3.16	40.30	24.59
R_Trunk_Rotation	-0.94	4.68	8.15	3.44	42.50	8.59	-1.31	4.16	6.70	17.11
L_Trunk_Rotation	-0.94	4.68	8.15	3.44	42.50	8.59	-1.31	4.16	6.70	17.11
R_Pelvis_Lat_Tilt	1.66	1.90	7.59	2.18	14.80	0.92	-4.96	1.70	59.70	0.95
L_Pelvis_Lat_Tilt	1.66	1.90	7.59	2.18	14.80	0.92	-4.73	1.47	59.20	1.03
R_Pelvis_Fwd_Tilt	11.83	5.39	12.76	4.92	20.90	18.35	10.26	5.15	33.20	22.14
L_Pelvis_Fwd_Tilt	11.83	5.39	12.76	4.92	20.90	18.35	10.26	5.16	33.00	21.88
R_Pelvis_Rotation	6.00	4.09	6.95	4.18	11.70	11.92	-4.99	4.13	53.00	3.71
L_Pelvis_Rotation	6.00	4.09	6.95	4.18	11.70	11.92	-4.99	4.13	53.00	3.71
R_Foot_Orientation	-12.21	6.76	-9.38	7.95	22.70	18.45	-13.94	7.15	37.00	20.15
L_Foot_Orientation	-13.11	5.25	-10.20	6.16	33.50	22.42	-14.72	5.59	39.80	14.23

Table B.26 Swing Phase Kinematics of 18-year-old Female Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Maximum Swing		**Time of Max. Sw.**		**Minimum Swing**		**Time of Min. Sw.**		**Toe Off**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	11.03	8.67	64.48	2.79	-8.73	6.38	98.28	1.03	10.04	8.38
L_Hip_Rot_Ang	6.79	3.86	65.52	7.53	-11.98	5.02	97.72	1.18	5.23	4.57
R_Hip_Abd_Ang	3.19	4.35	87.08	4.68	-6.10	2.78	65.58	1.26	-4.39	2.79
L_Hip_Abd_Ang	2.17	2.16	85.92	2.29	-6.99	2.18	65.32	1.81	-5.02	2.77
R_Hip_Flex_Ang	35.98	6.17	88.88	4.05	-5.03	4.64	60.68	0.94	-5.03	4.64
L_Hip_Flex_Ang	36.04	6.45	88.32	3.65	-4.86	5.72	60.22	0.90	-4.86	5.72
R_Knee_Rot_Ang	12.96	15.92	74.18	8.49	-17.25	11.42	89.88	11.45	-8.96	13.77
L_Knee_Rot_Ang	11.91	8.21	73.62	9.22	-16.03	6.98	79.62	17.65	-6.73	10.07
R_Knee_Abd_Ang	5.79	4.32	69.48	9.79	-4.67	4.26	85.78	9.55	2.57	3.24
L_Knee_Abd_Ang	3.06	2.57	71.92	14.49	-5.51	1.96	83.02	8.72	0.63	2.30
R_Knee_Flex_Ang	62.72	5.45	73.98	0.99	0.13	4.43	98.18	1.36	28.13	3.94
L_Knee_Flex_Ang	63.65	3.89	73.72	0.97	0.21	3.43	98.42	1.20	28.22	4.63
R_Ank_Rot_Ang	0.61	7.75	93.28	12.37	-31.42	10.52	72.98	4.30	-9.80	8.08
L_Ank_Rot_Ang	2.97	6.37	93.52	12.20	-27.72	4.51	72.22	3.54	-7.14	3.29
R_Ank_Abd_Ang	4.13	2.09	66.38	1.14	-2.11	1.81	84.18	8.24	1.42	1.13
L_Ank_Abd_Ang	4.70	1.51	66.92	0.92	-1.39	1.05	86.52	8.75	1.16	0.62
R_Ank_Flex_Ang	4.61	2.95	82.68	1.13	-10.65	3.30	63.58	0.81	-8.32	2.60
L_Ank_Flex_Ang	3.79	3.26	83.82	2.19	-13.17	3.24	64.02	1.03	-9.16	1.57
R_Elbow_Ang	43.08	8.88	60.68	0.94	23.11	8.87	98.98	0.26	43.08	8.88
L_Elbow_Ang	46.07	14.00	60.42	0.94	18.85	6.08	98.62	1.32	46.03	13.95
R_Shl_Add_Ang	24.20	2.50	98.98	0.26	12.56	3.37	67.38	6.53	14.98	3.86
L_Shl_Add_Ang	25.67	3.04	99.02	0.30	9.86	3.56	71.02	5.22	14.24	6.04
R_Shl_Flex_Ang	-9.25	33.68	62.08	3.27	-74.33	12.93	97.48	2.84	-9.41	33.81
L_Shl_Flex_Ang	26.96	32.04	60.22	0.90	-80.13	9.37	96.02	5.45	26.96	32.04
R_Trunk_Lat_Tilt	-0.08	2.83	71.58	14.38	-2.52	3.31	89.58	15.15	-0.51	2.64
L_Trunk_Lat_Tilt	-0.07	2.84	71.42	14.54	-2.52	3.31	89.62	15.11	-0.52	2.62
R_Trunk_Fwd_Tilt	-1.43	3.14	89.98	5.40	-4.04	3.25	62.68	1.10	-3.95	3.29
L_Trunk_Fwd_Tilt	-1.43	3.14	90.02	5.51	-4.04	3.25	62.72	1.15	-3.88	3.21
R_Trunk_Rotation	5.61	4.41	60.98	1.27	-1.98	4.77	93.18	6.77	5.59	4.38
L_Trunk_Rotation	5.65	4.38	60.72	1.09	-1.98	4.77	93.22	6.82	5.63	4.36
R_Pelvis_Lat_Tilt	0.98	1.48	93.38	4.91	-6.56	1.58	65.78	1.12	-5.39	1.70
L_Pelvis_Lat_Tilt	0.98	1.48	93.42	4.95	-6.56	1.58	65.82	0.99	-5.19	1.48
R_Pelvis_Fwd_Tilt	12.13	5.31	86.48	9.61	10.56	5.20	74.78	16.16	10.93	5.15
L_Pelvis_Fwd_Tilt	12.13	5.31	86.52	9.63	10.56	5.20	74.82	16.04	10.97	5.14
R_Pelvis_Rotation	5.13	4.19	98.18	2.38	-4.34	3.53	70.78	6.35	-3.53	3.93
L_Pelvis_Rotation	5.13	4.19	98.22	2.57	-4.34	3.53	70.82	6.64	-3.55	3.93
R_Foot_Orientation	-10.72	9.07	73.28	17.90	-22.22	7.89	83.08	5.78	-11.38	8.49
L_Foot_Orientation	-10.68	6.42	69.52	15.76	-22.10	6.42	83.52	5.46	-11.29	5.97

Table B.27 Stance Phase Kinematics of 18-year-old Male Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Foot Strike		**Maximum Stance**		**Time of Max. St.**		**Minimum Stance**		**Time of Min. St.**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-12.68	8.93	0.56	7.64	60.00	3.16	-12.89	8.96	3.73	8.79
L_Hip_Rot_Ang	-15.73	5.51	-4.96	5.91	42.91	20.95	-16.17	5.41	6.27	11.10
R_Hip_Abd_Ang	-0.70	3.25	3.93	3.32	24.36	11.97	-4.87	2.92	55.64	18.47
L_Hip_Abd_Ang	-2.61	2.13	2.59	2.32	27.09	14.34	-6.35	2.02	49.91	24.44
R_Hip_Flex_Ang	30.82	7.97	30.82	7.97	0.27	0.90	-5.45	6.65	53.27	1.27
L_Hip_Flex_Ang	32.30	7.82	32.31	7.81	0.18	0.60	-5.83	6.73	53.18	1.25
R_Knee_Rot_Ang	-12.76	12.48	2.50	11.05	38.82	25.50	-15.79	11.20	18.36	21.16
L_Knee_Rot_Ang	-5.49	12.89	15.33	8.39	47.00	22.58	-9.73	11.25	19.36	18.85
R_Knee_Abd_Ang	0.50	3.14	3.90	4.28	49.64	16.73	0.15	3.30	20.27	25.75
L_Knee_Abd_Ang	1.31	2.46	3.09	2.69	39.00	18.28	0.28	2.66	34.73	27.55
R_Knee_Flex_Ang	-3.31	4.51	28.92	5.02	61.00	1.10	-4.68	3.67	17.91	20.46
L_Knee_Flex_Ang	-2.51	5.15	30.89	3.26	60.73	0.79	-4.20	3.55	10.55	17.67
R_Ank_Rot_Ang	2.20	11.12	4.03	9.84	18.64	21.55	-14.43	8.95	29.73	24.81
L_Ank_Rot_Ang	-0.18	7.38	2.28	5.80	17.18	19.97	-20.90	6.03	33.91	25.01
R_Ank_Abd_Ang	-0.33	0.40	1.01	0.45	41.55	22.84	-1.40	1.71	23.18	21.06
L_Ank_Abd_Ang	-0.24	0.35	1.32	1.41	46.09	20.65	-1.97	0.94	46.73	14.44
R_Ank_Flex_Ang	-1.95	2.71	11.26	2.47	47.36	1.43	-6.31	3.91	31.45	28.31
L_Ank_Flex_Ang	-1.96	2.84	12.94	2.89	48.09	1.70	-5.17	3.64	25.64	27.47
R_Elbow_Ang	28.21	6.65	50.96	8.56	53.00	2.90	26.94	5.92	8.18	4.56
L_Elbow_Ang	25.61	6.98	52.42	6.80	53.55	3.67	24.09	6.54	7.55	4.87
R_Shl_Add_Ang	22.48	4.42	22.61	4.33	10.64	23.08	13.56	3.35	29.36	4.57
L_Shl_Add_Ang	22.51	4.12	23.56	4.14	18.00	24.48	12.44	3.25	24.64	5.26
R_Shl_Flex_Ang	-60.12	12.89	8.44	16.18	47.55	3.17	-61.99	11.70	5.45	3.91
L_Shl_Flex_Ang	-62.20	13.30	19.76	18.57	45.73	2.69	-63.63	13.28	5.55	4.68
R_Trunk_Lat_Tilt	-2.36	1.71	1.83	1.87	59.64	4.65	-3.98	1.25	15.18	4.33
L_Trunk_Lat_Tilt	-2.36	1.71	1.83	1.92	59.45	4.52	-3.98	1.25	15.18	4.33
R_Trunk_Fwd_Tilt	0.90	2.12	1.47	1.92	25.82	20.57	-0.95	2.22	52.09	19.85
L_Trunk_Fwd_Tilt	0.90	2.12	1.47	1.92	25.82	20.57	-0.95	2.26	51.82	19.70
R_Trunk_Rotation	-4.03	2.62	5.42	3.27	41.45	4.20	-4.06	2.60	0.64	2.11
L_Trunk_Rotation	-4.03	2.62	5.42	3.27	41.45	4.20	-4.06	2.60	0.64	2.11
R_Pelvis_Lat_Tilt	1.32	1.61	3.94	1.92	13.73	1.27	-2.18	1.98	58.73	7.62
L_Pelvis_Lat_Tilt	1.32	1.61	3.94	1.92	13.73	1.27	-2.21	2.06	56.45	9.89
R_Pelvis_Fwd_Tilt	12.85	5.66	13.75	5.46	40.64	14.21	11.80	5.62	25.73	23.32
L_Pelvis_Fwd_Tilt	12.85	5.66	13.75	5.46	40.64	14.21	11.80	5.62	25.64	23.17
R_Pelvis_Rotation	4.84	3.10	6.01	3.31	9.91	8.02	-4.41	1.89	56.55	3.27
L_Pelvis_Rotation	4.84	3.10	6.01	3.31	9.91	8.02	-4.42	1.90	57.36	3.14
R_Foot_Orientation	-18.19	7.47	-12.83	6.35	23.36	18.00	-18.24	7.38	3.82	12.66
L_Foot_Orientation	-18.43	6.87	-13.03	6.00	35.18	22.05	-18.52	6.73	7.91	17.61

Table B.28 Swing Phase Kinematics of 18-year-old Male Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Maximum Swing		**Time of Max. Sw.**		**Minimum Swing**		**Time of Min. Sw.**		**Toe Off**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	1.15	7.85	64.85	3.06	-12.76	8.86	98.21	1.55	0.60	7.68
L_Hip_Rot_Ang	-4.61	5.52	70.36	9.27	-16.77	5.34	98.27	0.93	-6.05	5.83
R_Hip_Abd_Ang	-0.59	3.12	93.12	4.61	-6.55	3.01	66.76	1.96	-5.32	2.98
L_Hip_Abd_Ang	-2.40	1.97	91.82	11.27	-7.95	2.05	66.82	2.20	-6.53	2.40
R_Hip_Flex_Ang	31.94	6.94	90.67	3.60	0.74	7.21	61.85	1.06	0.74	7.21
L_Hip_Flex_Ang	33.69	6.39	90.00	3.20	0.34	6.52	61.63	0.81	0.34	6.52
R_Knee_Rot_Ang	10.62	10.69	72.76	2.56	-15.26	12.36	95.76	3.35	-0.15	10.24
L_Knee_Rot_Ang	25.69	9.17	73.54	2.21	-7.63	12.13	96.72	2.56	14.44	7.69
R_Knee_Abd_Ang	6.43	5.84	77.67	8.35	-0.12	3.27	88.30	11.82	3.91	4.85
L_Knee_Abd_Ang	4.54	3.65	84.91	9.59	-2.02	2.59	79.72	12.50	1.68	3.19
R_Knee_Flex_Ang	57.10	5.31	73.67	1.20	-3.80	3.85	98.67	0.48	32.18	5.10
L_Knee_Flex_Ang	60.54	4.56	74.00	1.07	-2.82	4.34	98.82	0.40	34.26	3.32
R_Ank_Rot_Ang	3.35	10.98	98.39	0.75	-22.55	8.67	74.03	3.38	-11.50	9.00
L_Ank_Rot_Ang	1.38	6.69	98.18	1.27	-31.32	5.22	74.72	2.93	-18.73	3.97
R_Ank_Abd_Ang	2.84	1.92	67.21	1.63	-1.63	1.40	85.39	7.63	0.96	0.65
L_Ank_Abd_Ang	3.58	3.60	66.91	1.51	-2.65	1.69	82.63	5.65	1.38	2.02
R_Ank_Flex_Ang	4.11	2.69	84.12	4.94	-9.46	7.53	65.85	1.11	-6.13	4.81
L_Ank_Flex_Ang	5.23	3.77	84.54	4.13	-7.32	6.82	69.00	10.08	-3.64	5.17
R_Elbow_Ang	47.60	8.75	61.85	1.06	27.43	6.63	96.30	6.90	47.60	8.75
L_Elbow_Ang	48.21	8.15	61.63	0.81	24.68	6.91	95.36	7.14	48.21	8.15
R_Shl_Add_Ang	22.53	3.99	94.94	10.51	15.85	2.95	72.39	6.95	17.22	3.40
L_Shl_Add_Ang	22.63	3.69	93.36	10.94	15.86	3.59	69.09	7.56	17.82	4.18
R_Shl_Flex_Ang	-6.66	17.26	61.85	1.06	-60.53	12.49	98.85	0.26	-6.66	17.26
L_Shl_Flex_Ang	1.45	20.18	61.63	0.81	-62.50	12.58	98.91	0.25	1.45	20.18
R_Trunk_Lat_Tilt	2.18	2.07	66.21	2.64	-2.07	1.88	98.57	1.04	1.91	1.92
L_Trunk_Lat_Tilt	2.18	2.07	66.27	2.63	-2.07	1.88	98.63	1.02	1.91	1.96
R_Trunk_Fwd_Tilt	0.54	2.02	91.76	2.80	-1.03	2.19	66.85	10.73	-0.95	2.17
L_Trunk_Fwd_Tilt	0.54	2.02	91.82	2.74	-1.03	2.19	66.82	10.73	-0.96	2.19
R_Trunk_Rotation	2.10	2.93	61.85	1.06	-4.48	2.43	93.67	5.44	2.10	2.93
L_Trunk_Rotation	2.20	2.96	61.63	0.81	-4.48	2.43	93.72	5.41	2.20	2.96
R_Pelvis_Lat_Tilt	1.75	1.29	88.48	5.54	-2.63	2.06	67.67	10.51	-2.34	2.02
L_Pelvis_Lat_Tilt	1.75	1.29	88.54	5.59	-2.64	2.06	67.63	10.52	-2.36	2.08
R_Pelvis_Fwd_Tilt	12.76	5.49	82.39	17.25	11.42	5.79	81.94	11.98	12.32	5.49
L_Pelvis_Fwd_Tilt	12.78	5.50	79.00	17.67	11.42	5.79	82.00	11.97	12.36	5.49
R_Pelvis_Rotation	3.77	2.70	95.94	9.65	-4.34	1.84	67.21	8.76	-4.06	1.79
L_Pelvis_Rotation	3.77	2.70	96.00	9.72	-4.37	1.86	66.91	8.87	-4.10	1.83
R_Foot_Orientation	-14.35	6.59	65.30	6.65	-23.53	8.72	89.57	6.18	-14.97	6.97
L_Foot_Orientation	-13.69	6.93	66.09	4.84	-23.20	8.24	88.00	4.86	-14.48	6.84

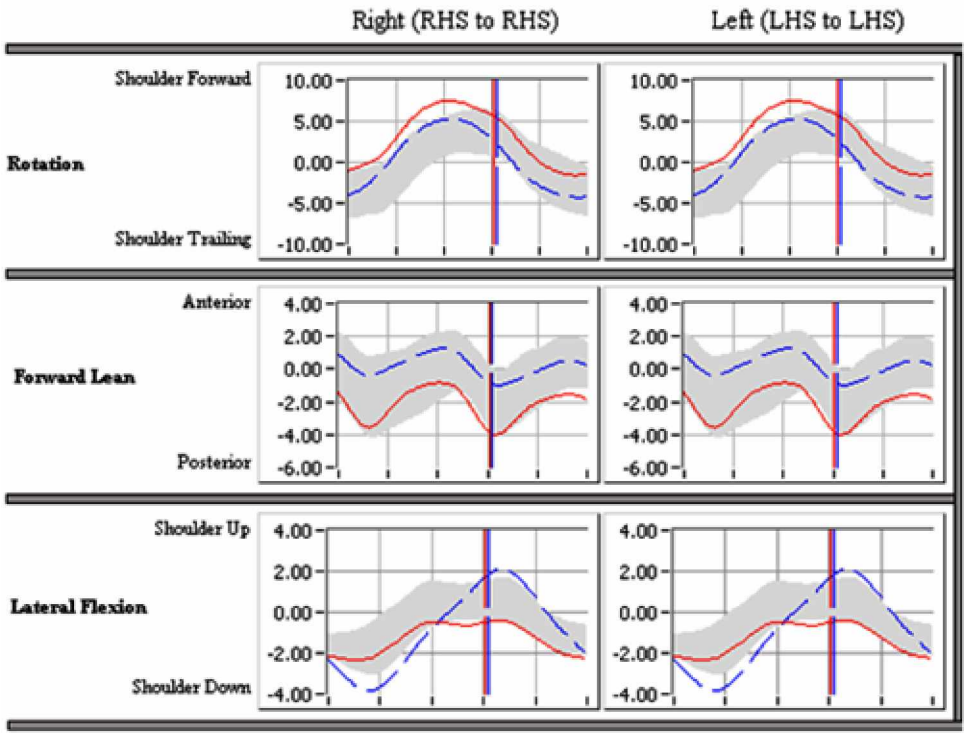

Figure B.43 Trunk Orientation Relative to Room (Degrees), 18-year-old subjects.

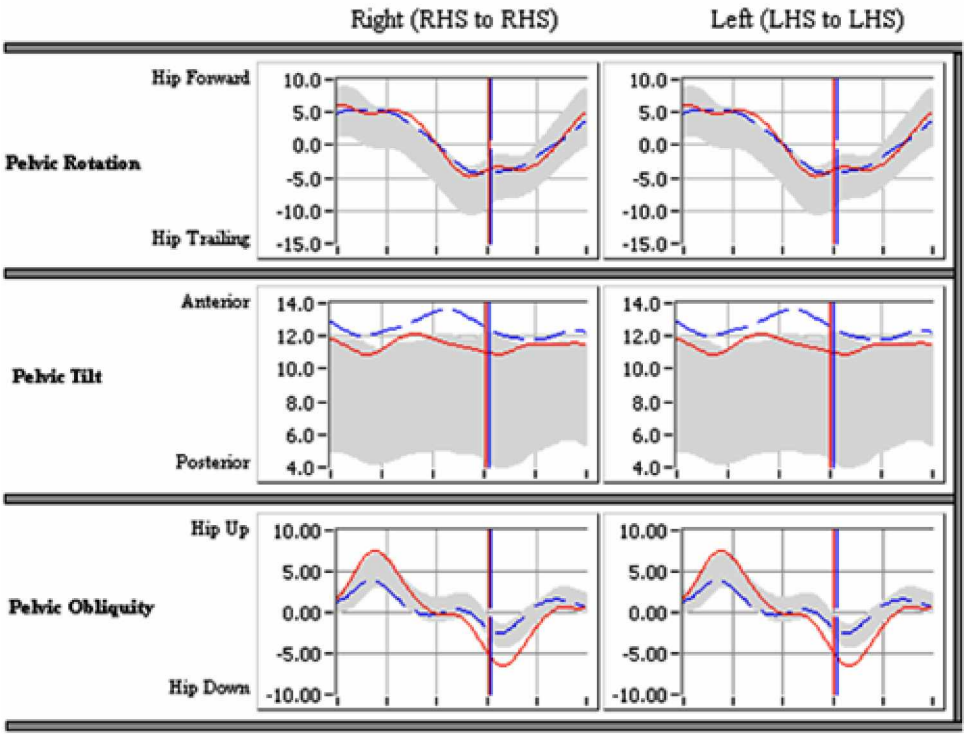

Figure B.44 Pelvis Orientation Relative to Room (Degrees), 18-year-old subjects.

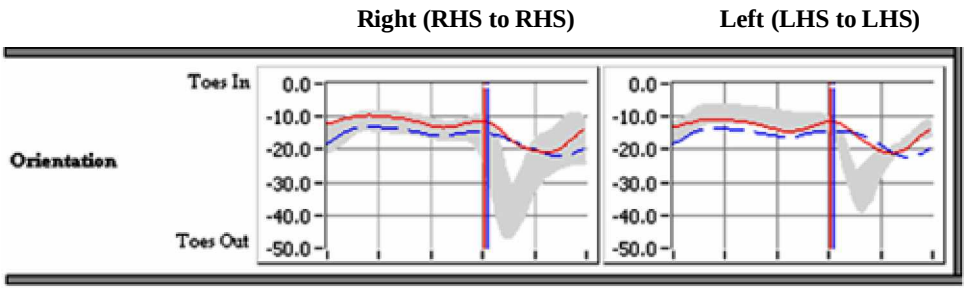

Figure B.45 Foot Orientation Relative to Room (Degrees), 18-year-old subjects.

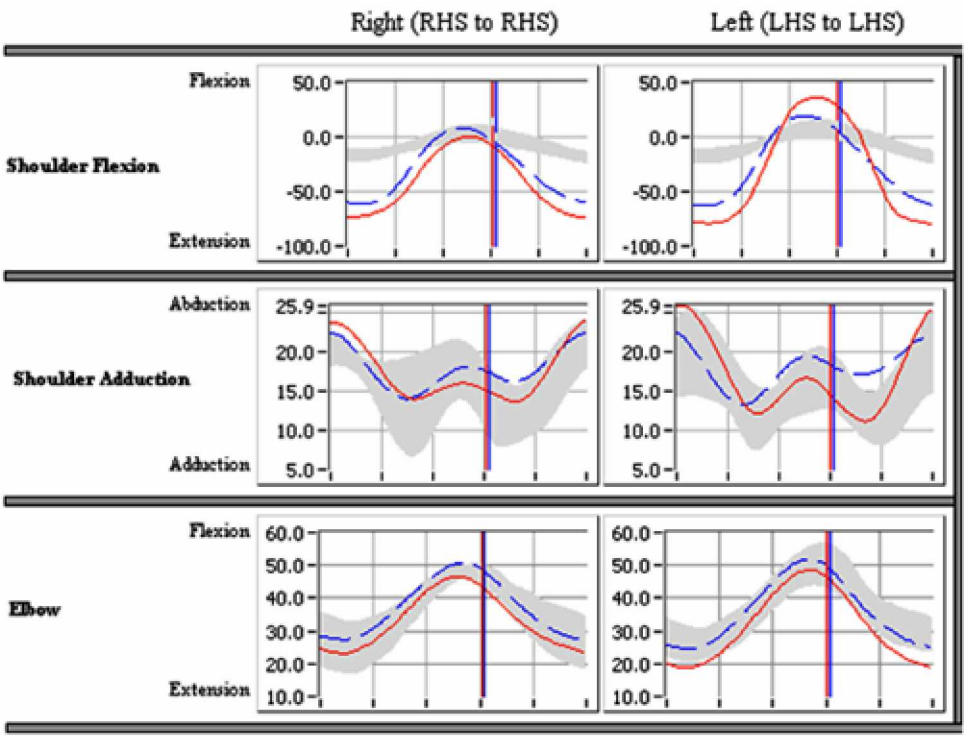

Figure B.46 Arm Joint Angles (Degrees), 18-year-old subjects.

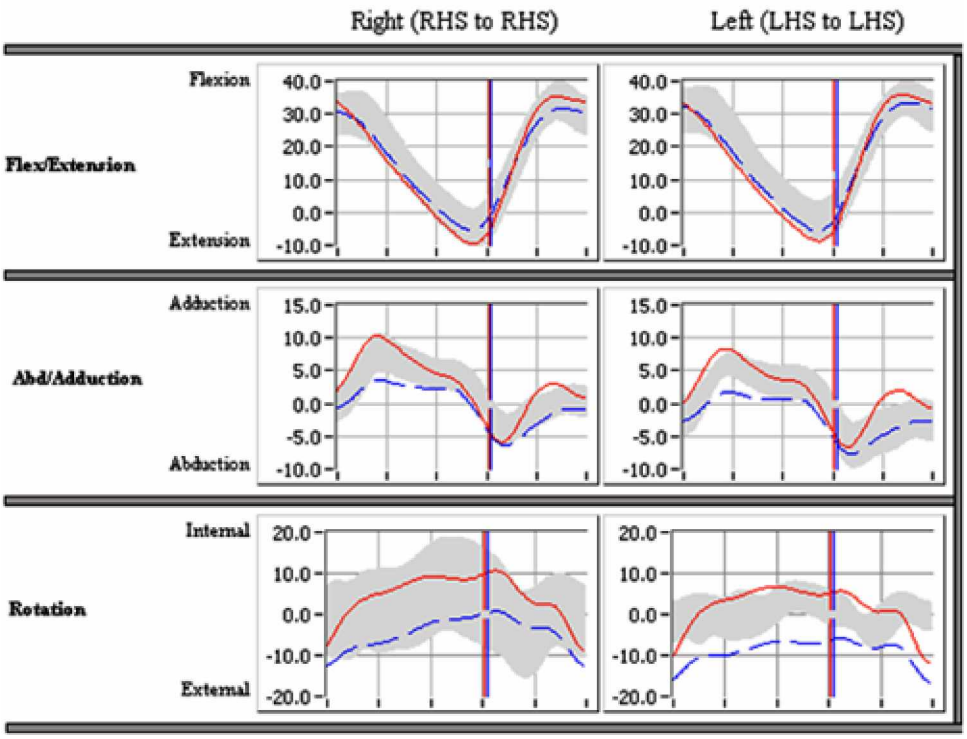

Figure B.47 Hip Joint Angles (Degrees), 18-year-old subjects.

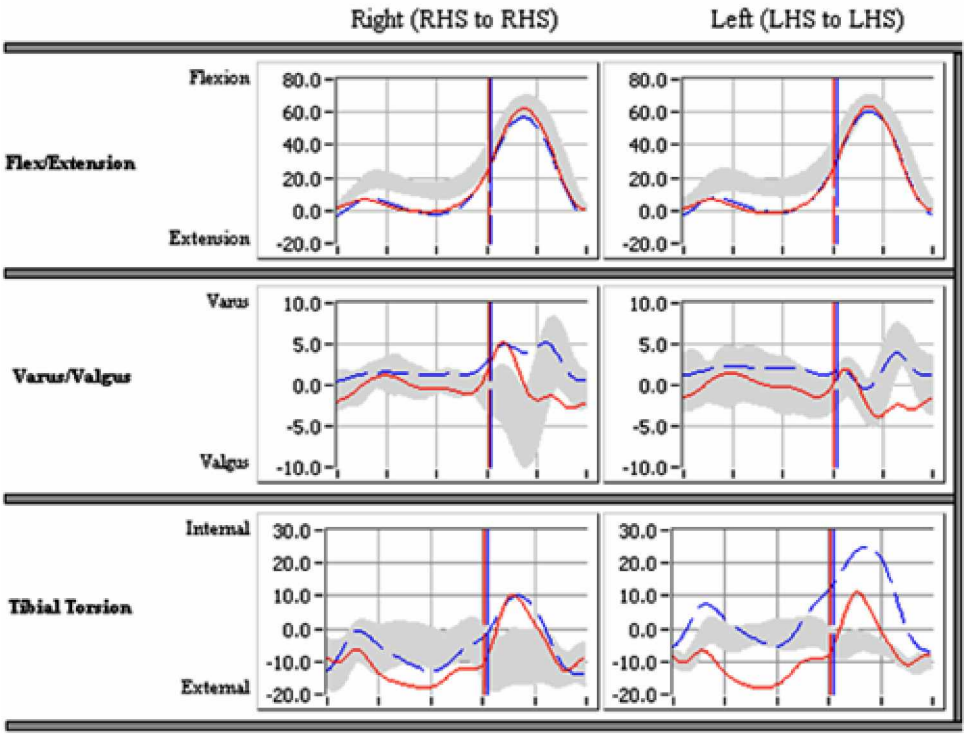

Figure B.48 Knee Joint Angles (Degrees), 18-year-old subjects.

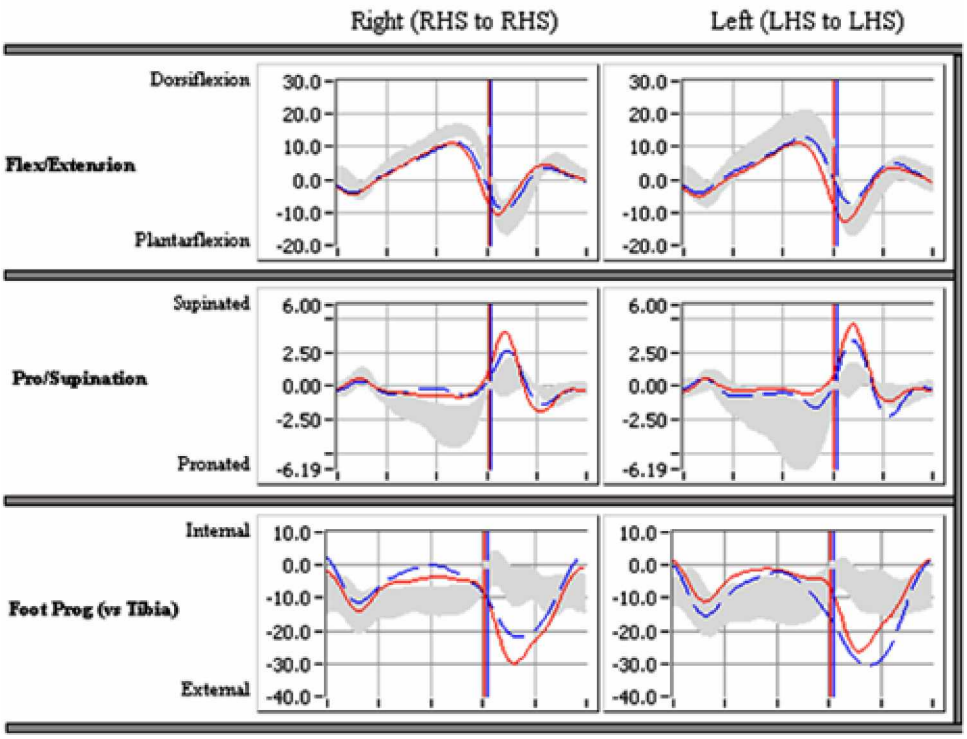

Figure B.49 Ankle Joint Angles (Degrees), 18-year-old subjects.

Twenty-Year-Old Subjects

Table B.29 Stance Phase Kinematics of 20-year-old Female Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Foot Strike		**Maximum Stance**		**Time of Max. St.**		**Minimum Stance**		**Time of Min. St.**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-12.71	7.32	1.17	8.31	45.80	11.98	-12.71	7.32	0.00	0.00
L_Hip_Rot_Ang	-6.68	8.37	6.12	5.88	30.90	12.71	-6.68	8.37	0.00	0.00
R_Hip_Abd_Ang	3.38	3.42	9.77	3.76	13.90	2.13	-4.76	2.59	60.10	1.85
L_Hip_Abd_Ang	3.18	2.48	8.25	2.82	13.10	1.66	-6.76	3.21	60.30	0.48
R_Hip_Flex_Ang	32.70	2.79	32.70	2.79	0.00	0.00	-7.75	3.06	49.40	2.12
L_Hip_Flex_Ang	34.34	3.87	34.34	3.87	0.00	0.00	-10.12	3.45	49.50	2.27
R_Knee_Rot_Ang	1.11	16.84	17.01	15.26	52.50	16.54	-8.40	11.78	25.80	18.12
L_Knee_Rot_Ang	-0.90	11.95	15.87	8.69	52.30	16.19	-14.11	7.71	29.70	15.74
R_Knee_Abd_Ang	-1.54	4.10	2.93	5.01	40.80	14.94	-4.35	5.06	44.00	24.83
L_Knee_Abd_Ang	-2.08	2.66	2.57	2.90	46.90	14.22	-2.58	2.97	33.00	27.19
R_Knee_Flex_Ang	4.94	5.68	42.19	8.23	60.70	0.95	-1.14	4.80	31.30	11.49
L_Knee_Flex_Ang	7.07	8.84	40.88	8.54	60.30	0.48	-0.46	3.18	29.70	15.72
R_Ank_Rot_Ang	-3.10	6.31	2.21	5.85	24.20	21.07	-23.24	10.07	55.90	15.45
L_Ank_Rot_Ang	-5.53	10.43	2.91	9.67	32.00	16.96	-23.59	10.85	47.00	20.89
R_Ank_Abd_Ang	-0.12	0.39	2.43	0.97	60.70	0.95	-1.97	1.89	37.60	16.04
L_Ank_Abd_Ang	-0.33	0.66	2.54	0.73	52.60	10.21	-2.15	1.00	27.70	15.96
R_Ank_Flex_Ang	-1.67	1.69	13.22	3.30	43.20	2.15	-6.81	3.28	49.30	23.36
L_Ank_Flex_Ang	-0.85	3.64	13.71	2.50	42.60	2.07	-6.41	2.48	60.30	0.48
R_Elbow_Ang	24.59	5.95	52.43	7.06	51.70	2.91	24.06	5.56	4.30	2.79
L_Elbow_Ang	21.86	6.31	52.46	5.93	54.20	5.49	20.74	5.97	6.50	1.96
R_Shl_Add_Ang	25.29	1.91	25.41	1.81	9.60	19.72	13.51	4.81	32.40	7.23
L_Shl_Add_Ang	23.91	3.80	24.01	3.92	1.00	1.33	11.46	3.38	49.00	14.48
R_Shl_Flex_Ang	-71.69	12.16	1.61	24.81	47.30	1.57	-72.52	12.11	4.50	5.23
L_Shl_Flex_Ang	-72.24	5.51	13.42	35.12	48.80	1.69	-74.07	5.92	6.30	6.18
R_Trunk_Lat_Tilt	-1.70	1.61	1.11	1.70	55.10	4.41	-2.47	1.54	11.40	3.66
L_Trunk_Lat_Tilt	-1.70	1.61	1.11	1.70	55.10	4.41	-2.47	1.54	11.40	3.66
R_Trunk_Fwd_Tilt	-1.86	1.49	-0.44	1.43	34.00	13.56	-2.78	1.49	13.90	16.37
L_Trunk_Fwd_Tilt	-1.86	1.49	-0.44	1.43	34.00	13.56	-2.78	1.49	13.90	16.37
R_Trunk_Rotation	-1.79	2.28	7.22	3.63	39.00	4.19	-1.79	2.28	0.00	0.00
L_Trunk_Rotation	-1.79	2.28	7.22	3.63	39.00	4.19	-1.79	2.28	0.00	0.00
R_Pelvis_Lat_Tilt	3.57	1.34	7.53	1.63	12.80	1.40	-5.34	1.00	59.70	2.06
L_Pelvis_Lat_Tilt	3.57	1.34	7.53	1.63	12.80	1.40	-5.33	0.91	59.50	1.90
R_Pelvis_Fwd_Tilt	10.89	3.92	12.36	4.12	34.80	14.11	10.10	4.21	39.70	27.32
L_Pelvis_Fwd_Tilt	10.89	3.92	12.36	4.12	34.80	14.11	10.14	4.18	39.40	27.06
R_Pelvis_Rotation	5.02	1.74	6.33	3.07	15.80	14.13	-3.38	5.73	46.50	19.86
L_Pelvis_Rotation	5.02	1.74	6.33	3.07	15.80	14.13	-3.37	5.73	43.80	18.07
R_Foot_Orientation	-8.00	6.75	-4.24	5.97	34.70	20.89	-8.27	6.51	18.00	23.94
L_Foot_Orientation	-8.45	2.63	-4.04	3.30	48.70	18.39	-9.74	2.33	48.90	10.05

Table B.30 Swing Phase Kinematics of 20-year-old Female Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Maximum Swing		**Time of Max. Sw.**		**Minimum Swing**		**Time of Min. Sw.**		**Toe Off**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-0.96	7.92	63.86	6.25	-14.96	7.89	97.36	0.66	-1.19	8.16
L_Hip_Rot_Ang	5.06	6.18	61.57	1.22	-9.42	8.37	97.17	1.98	5.02	6.20
R_Hip_Abd_Ang	3.21	3.11	86.46	6.69	-4.90	2.39	62.66	1.57	-4.79	2.49
L_Hip_Abd_Ang	2.20	2.16	89.27	7.46	-7.41	3.29	63.07	1.70	-7.02	3.30
R_Hip_Flex_Ang	33.50	2.63	86.96	6.15	3.39	3.53	61.66	0.87	3.39	3.53
L_Hip_Flex_Ang	36.27	4.16	90.37	5.91	1.84	3.71	61.17	0.59	1.84	3.71
R_Knee_Rot_Ang	22.93	13.24	67.86	1.66	-7.56	20.27	93.26	2.68	17.87	15.59
L_Knee_Rot_Ang	25.95	8.94	68.27	3.24	-9.23	13.00	91.97	4.68	16.59	9.44
R_Knee_Abd_Ang	1.65	6.60	82.56	16.78	-8.81	7.81	79.36	10.77	-2.02	8.51
L_Knee_Abd_Ang	1.43	4.30	73.27	13.96	-7.87	6.58	78.77	10.94	0.33	5.09
R_Knee_Flex_Ang	61.11	7.15	70.56	1.38	1.03	4.84	96.76	1.06	45.33	8.32
L_Knee_Flex_Ang	64.71	6.75	70.97	1.79	4.39	7.25	96.77	2.13	44.33	8.69
R_Ank_Rot_Ang	2.75	7.50	95.66	0.81	-34.18	11.13	70.56	1.16	-24.65	10.27
L_Ank_Rot_Ang	0.98	12.04	95.37	2.68	-37.81	11.34	69.77	2.05	-24.80	11.39
R_Ank_Abd_Ang	3.33	1.33	63.96	0.81	-2.65	1.74	78.46	0.90	2.84	1.08
L_Ank_Abd_Ang	3.55	0.86	64.07	0.93	-3.19	1.42	82.27	8.21	2.83	0.76
R_Ank_Flex_Ang	5.02	1.85	81.36	2.32	-7.07	3.17	62.36	0.99	-6.94	3.16
L_Ank_Flex_Ang	5.20	1.78	81.97	1.96	-6.95	2.36	62.07	1.06	-6.82	2.43
R_Elbow_Ang	48.16	7.61	61.66	0.87	23.92	5.40	98.96	0.27	48.16	7.61
L_Elbow_Ang	47.35	9.77	61.37	0.57	21.65	6.04	98.87	0.21	47.34	9.77
R_Shl_Add_Ang	26.76	2.50	98.66	0.68	14.68	4.08	65.76	4.81	14.98	4.37
L_Shl_Add_Ang	24.02	3.29	97.67	1.86	11.01	3.92	68.67	4.44	12.44	3.90
R_Shl_Flex_Ang	-20.18	23.24	61.66	0.87	-73.60	12.66	97.66	3.25	-20.18	23.24
L_Shl_Flex_Ang	2.15	31.10	61.17	0.59	-74.48	7.75	97.97	2.86	2.15	31.10
R_Trunk_Lat_Tilt	1.07	2.00	63.16	3.68	-1.63	1.83	94.46	7.41	0.96	1.87
L_Trunk_Lat_Tilt	1.09	1.97	62.67	3.70	-1.63	1.83	94.37	7.17	0.99	1.84
R_Trunk_Fwd_Tilt	-1.46	1.71	84.36	9.15	-2.81	1.60	85.06	17.77	-2.45	1.58
L_Trunk_Fwd_Tilt	-1.46	1.71	84.27	9.22	-2.80	1.61	85.07	17.84	-2.44	1.57
R_Trunk_Rotation	3.54	4.18	61.66	0.87	-1.73	2.64	89.36	9.53	3.54	4.18
L_Trunk_Rotation	3.70	4.15	61.17	0.59	-1.73	2.64	89.27	9.43	3.70	4.15
R_Pelvis_Lat_Tilt	2.98	1.41	97.46	4.57	-5.31	0.96	62.06	0.92	-5.27	1.02
L_Pelvis_Lat_Tilt	2.98	1.41	97.37	4.75	-5.33	0.94	61.77	0.66	-5.29	0.95
R_Pelvis_Fwd_Tilt	10.79	4.26	73.26	12.10	9.88	4.20	83.26	11.67	10.47	4.06
L_Pelvis_Fwd_Tilt	10.78	4.26	73.27	12.20	9.88	4.20	83.17	11.65	10.50	4.04
R_Pelvis_Rotation	5.97	2.55	98.86	0.25	-3.01	4.50	70.96	7.07	-1.96	5.59
L_Pelvis_Rotation	5.97	2.55	98.77	0.38	-3.00	4.49	70.97	6.99	-1.94	5.57
R_Foot_Orientation	-7.69	6.84	65.46	11.94	-19.14	9.43	80.96	4.19	-7.73	6.90
L_Foot_Orientation	-6.62	4.20	61.17	0.59	-20.17	3.71	79.57	4.43	-6.62	4.20

Table B.31 Stance Phase Kinematics of 20-year-old Male Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	-12.44	6.18	1.62	7.14	59.67	3.32	-12.66	6.33	1.56	4.67
L_Hip_Rot_Ang	-10.98	6.59	0.45	5.41	49.89	13.85	-11.32	6.94	2.00	5.27
R_Hip_Abd_Ang	-1.28	2.74	3.62	2.73	23.78	12.19	-4.68	2.42	60.89	0.78
L_Hip_Abd_Ang	-2.24	1.64	1.67	2.32	19.44	9.32	-7.06	1.47	60.56	0.53
R_Hip_Flex_Ang	27.56	7.21	27.60	7.20	1.00	1.50	-7.30	6.91	53.67	0.50
L_Hip_Flex_Ang	28.53	6.99	28.54	6.98	0.22	0.67	-8.69	7.22	53.33	1.00
R_Knee_Rot_Ang	-15.22	13.20	1.01	15.06	44.44	24.60	-19.58	8.75	25.11	20.00
L_Knee_Rot_Ang	-10.58	9.99	10.97	10.15	48.89	21.31	-12.76	9.23	16.44	19.93
R_Knee_Abd_Ang	2.60	2.49	5.86	3.29	49.22	18.19	2.35	2.48	9.11	18.74
L_Knee_Abd_Ang	2.76	1.04	5.53	2.89	35.22	21.32	2.01	1.87	19.44	29.26
R_Knee_Flex_Ang	-4.54	3.16	28.95	3.64	60.89	0.78	-5.20	3.49	18.78	20.95
L_Knee_Flex_Ang	-4.84	3.40	28.75	4.73	60.56	0.53	-4.89	3.45	8.67	17.20
R_Ank_Rot_Ang	3.64	9.79	6.92	6.18	19.22	22.84	-13.25	9.00	34.00	25.86
L_Ank_Rot_Ang	3.58	7.26	5.32	6.31	13.67	20.50	-17.41	9.94	39.44	24.42
R_Ank_Abd_Ang	-0.05	0.59	1.19	0.60	36.44	23.27	-0.74	0.21	21.11	22.18
L_Ank_Abd_Ang	-0.21	0.42	1.76	1.44	41.33	20.53	-1.40	0.88	38.00	24.53
R_Ank_Flex_Ang	-3.15	2.24	11.53	2.73	47.22	1.30	-7.07	3.64	30.22	29.25
L_Ank_Flex_Ang	-3.40	1.33	12.62	2.79	47.89	1.90	-5.73	3.12	23.33	28.05
R_Elbow_Ang	28.96	10.35	55.48	10.01	51.78	4.87	27.45	8.63	6.89	4.73
L_Elbow_Ang	26.26	7.41	52.73	7.08	54.78	4.52	23.36	6.48	10.44	3.91
R_Shl_Add_Ang	23.84	3.84	23.87	3.87	5.78	16.96	15.86	3.94	30.67	4.50
L_Shl_Add_Ang	23.66	4.08	24.18	4.02	6.22	17.57	15.19	5.83	27.78	3.49
R_Shl_Flex_Ang	-59.87	9.68	2.10	24.77	47.44	2.51	-60.33	9.80	3.00	2.12
L_Shl_Flex_Ang	-52.62	11.95	18.34	16.80	47.11	2.26	-53.89	12.36	5.00	2.40
R_Trunk_Lat_Tilt	-2.39	1.87	1.22	1.32	56.78	6.67	-3.47	1.91	14.33	3.12
L_Trunk_Lat_Tilt	-2.39	1.87	1.21	1.38	56.56	6.48	-3.47	1.91	14.33	3.12
R_Trunk_Fwd_Tilt	0.75	1.35	1.29	1.41	30.67	17.44	-1.16	1.60	60.89	0.78
L_Trunk_Fwd_Tilt	0.75	1.35	1.29	1.41	30.67	17.44	-1.15	1.63	60.56	0.53
R_Trunk_Rotation	-2.35	1.38	5.78	2.86	42.89	5.60	-2.40	1.41	1.44	2.46
L_Trunk_Rotation	-2.35	1.38	5.78	2.86	42.89	5.60	-2.40	1.41	1.44	2.46
R_Pelvis_Lat_Tilt	1.72	0.90	4.46	1.69	14.00	1.32	-2.02	2.15	58.11	8.33
L_Pelvis_Lat_Tilt	1.72	0.90	4.46	1.69	14.00	1.32	-2.03	2.21	55.33	10.69
R_Pelvis_Fwd_Tilt	10.89	5.80	12.06	5.56	44.89	3.44	9.61	5.94	18.44	16.59
L_Pelvis_Fwd_Tilt	10.89	5.80	12.06	5.56	44.89	3.44	9.62	5.94	18.33	16.26
R_Pelvis_Rotation	6.23	3.10	6.74	2.84	8.78	7.89	-2.62	1.77	55.44	3.05
L_Pelvis_Rotation	6.23	3.10	6.74	2.84	8.78	7.89	-2.62	1.77	56.33	3.08
R_Foot_Orientation	-17.33	6.75	-12.51	6.33	30.67	21.17	-17.76	6.63	14.22	21.34
L_Foot_Orientation	-15.96	6.35	-10.65	5.13	35.00	21.64	-16.27	6.03	14.67	22.02

Table B.32 Swing Phase Kinematics of 20-year-old Male Subjects
(Max = Maximum, St. = Stance, Min = Minimum, R = Right, L = Left, Rot = Rotation, Ang = Angle, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Add = Adduction, Lat = Lateral, Fwd = Forward)

	Maximum Swing		**Time of Max. Sw.**		**Minimum Swing**		**Time of Min. Sw.**		**Toe Off**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Ang	1.93	7.42	63.87	2.27	-12.70	5.48	98.31	0.88	1.60	7.27
L_Hip_Rot_Ang	2.40	7.64	74.92	11.21	-11.61	7.02	98.59	0.33	-0.69	6.76
R_Hip_Abd_Ang	-1.43	2.56	95.31	5.02	-6.17	2.41	66.53	1.46	-5.14	2.45
L_Hip_Abd_Ang	-2.57	1.75	96.92	3.70	-8.69	1.50	66.48	1.90	-7.54	1.49
R_Hip_Flex_Ang	29.36	6.38	88.53	1.64	-1.26	7.29	61.76	0.74	-1.26	7.29
L_Hip_Flex_Ang	30.24	6.22	88.70	2.11	-2.71	7.36	61.59	0.65	-2.71	7.36
R_Knee_Rot_Ang	14.13	18.85	73.31	2.57	-17.01	14.06	96.76	3.37	-1.01	15.44
L_Knee_Rot_Ang	26.69	10.17	72.81	1.74	-12.37	9.68	97.92	1.71	11.07	9.05
R_Knee_Abd_Ang	8.48	4.03	76.42	9.86	1.98	2.71	89.98	10.38	5.98	3.71
L_Knee_Abd_Ang	8.52	4.81	83.37	9.37	0.19	3.45	81.70	13.33	4.70	4.21
R_Knee_Flex_Ang	60.10	3.32	73.87	0.41	-4.55	2.87	98.76	0.44	32.45	3.51
L_Knee_Flex_Ang	60.59	4.08	74.26	0.64	-5.28	3.46	99.03	0.27	32.21	4.71
R_Ank_Rot_Ang	5.05	10.41	98.20	0.76	-24.68	13.82	74.31	3.23	-11.31	11.08
L_Ank_Rot_Ang	4.96	7.59	98.48	0.53	-30.82	10.88	73.59	2.72	-16.53	8.36
R_Ank_Abd_Ang	2.78	2.30	66.98	1.56	-2.08	1.90	81.87	4.34	1.02	0.97
L_Ank_Abd_Ang	3.61	3.80	66.92	1.22	-2.47	1.69	86.59	9.35	1.50	2.10
R_Ank_Flex_Ang	4.09	2.32	83.87	5.68	-8.84	8.62	72.87	14.95	-5.59	5.59
L_Ank_Flex_Ang	4.21	3.54	83.26	1.31	-7.27	6.89	69.48	11.15	-3.87	5.19
R_Elbow_Ang	51.72	10.51	66.20	8.96	27.70	9.77	90.98	14.26	51.28	10.95
L_Elbow_Ang	49.37	9.28	61.59	0.65	24.45	6.78	92.37	12.50	49.37	9.28
R_Shl_Add_Ang	24.19	3.33	95.20	6.48	17.80	3.33	67.87	4.93	18.88	3.59
L_Shl_Add_Ang	23.64	3.16	91.81	12.48	17.05	4.08	70.15	8.20	19.24	4.34
R_Shl_Flex_Ang	-12.05	22.24	61.76	0.74	-60.49	11.28	98.87	0.26	-12.05	22.24
L_Shl_Flex_Ang	3.69	17.38	61.59	0.65	-52.42	12.46	99.03	0.27	3.69	17.38
R_Trunk_Lat_Tilt	1.34	1.50	64.76	2.89	-2.36	1.86	98.53	1.15	1.18	1.39
L_Trunk_Lat_Tilt	1.34	1.50	64.92	3.03	-2.36	1.86	98.70	1.17	1.17	1.44
R_Trunk_Fwd_Tilt	0.25	1.31	92.20	2.97	-1.21	1.60	63.09	1.37	-1.18	1.59
L_Trunk_Fwd_Tilt	0.25	1.31	92.37	2.76	-1.21	1.59	63.15	1.34	-1.18	1.62
R_Trunk_Rotation	3.01	1.99	61.76	0.74	-2.74	1.17	94.65	6.34	3.01	1.99
L_Trunk_Rotation	3.13	2.07	61.59	0.65	-2.74	1.17	94.81	6.34	3.13	2.07
R_Pelvis_Lat_Tilt	2.10	0.90	88.53	4.10	-2.34	2.27	63.87	1.11	-2.17	2.19
L_Pelvis_Lat_Tilt	2.10	0.90	88.70	4.09	-2.34	2.27	64.03	1.29	-2.16	2.24
R_Pelvis_Fwd_Tilt	10.56	5.71	83.87	17.10	9.29	5.99	77.98	9.37	10.20	5.79
L_Pelvis_Fwd_Tilt	10.58	5.72	79.81	17.99	9.29	5.99	78.15	9.29	10.23	5.79
R_Pelvis_Rotation	5.25	3.07	98.42	0.87	-2.81	1.86	64.42	3.46	-2.52	1.77
L_Pelvis_Rotation	5.25	3.07	98.59	0.72	-2.83	1.87	64.26	3.77	-2.55	1.82
R_Foot_Orientation	-13.39	5.87	64.98	6.77	-20.83	7.13	90.65	7.05	-13.79	6.44
L_Foot_Orientation	-10.90	5.87	67.03	4.03	-18.60	7.82	91.03	5.84	-11.66	5.88

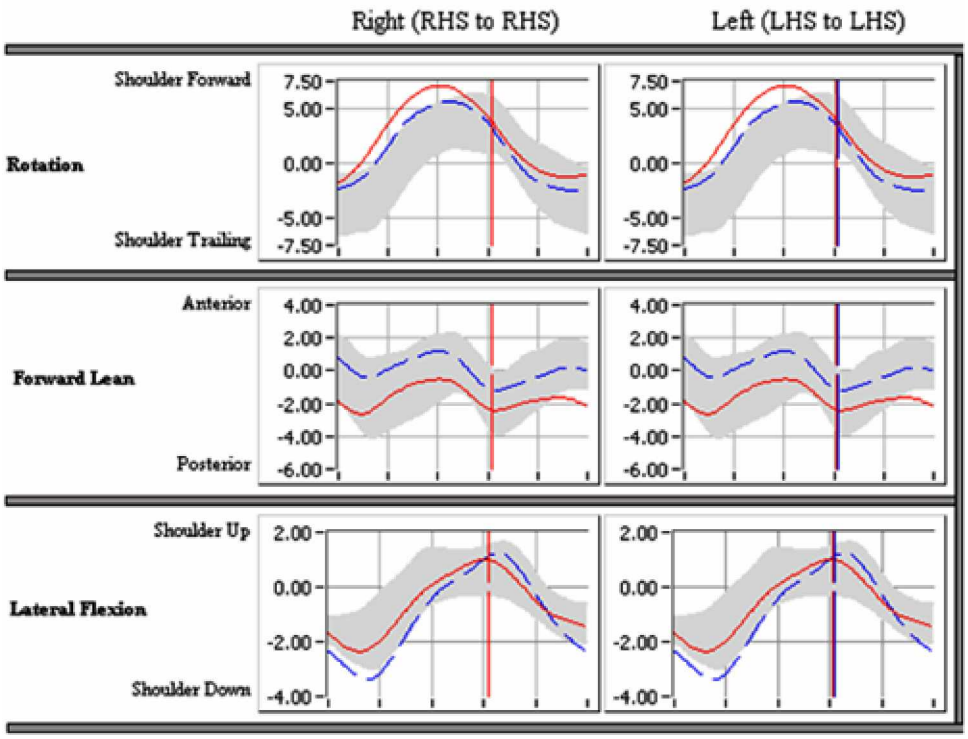

Figure B.50 Trunk Orientation Relative to Room (Degrees), 20-year-old subjects.

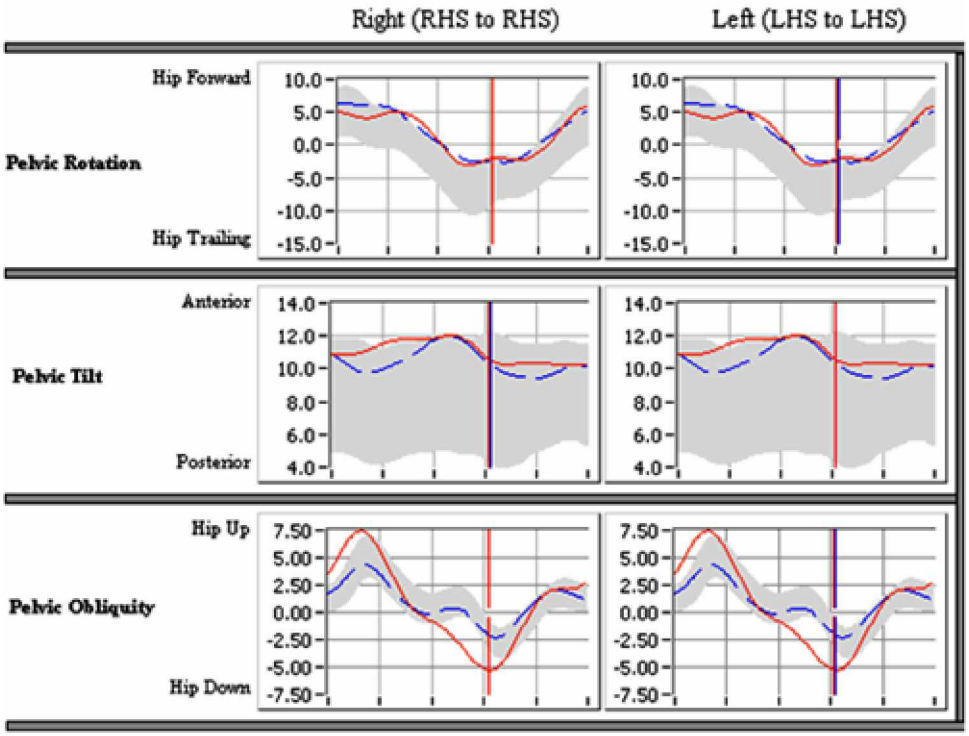

Figure B.51 Pelvis Orientation Relative to Room (Degrees), 20-year-old subjects.

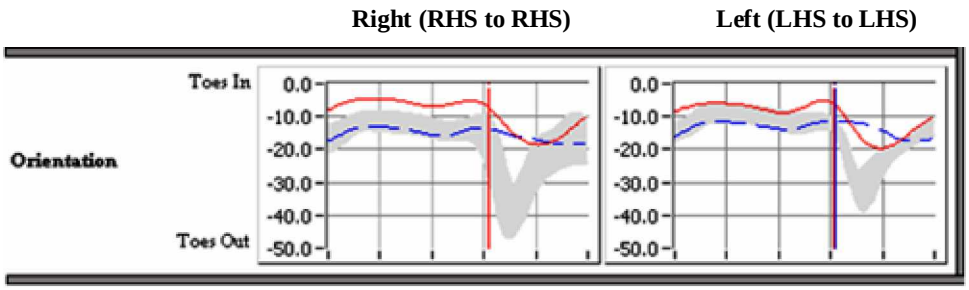

Figure B.52 Foot Orientation Relative to Room (Degrees), 20-year-old subjects.

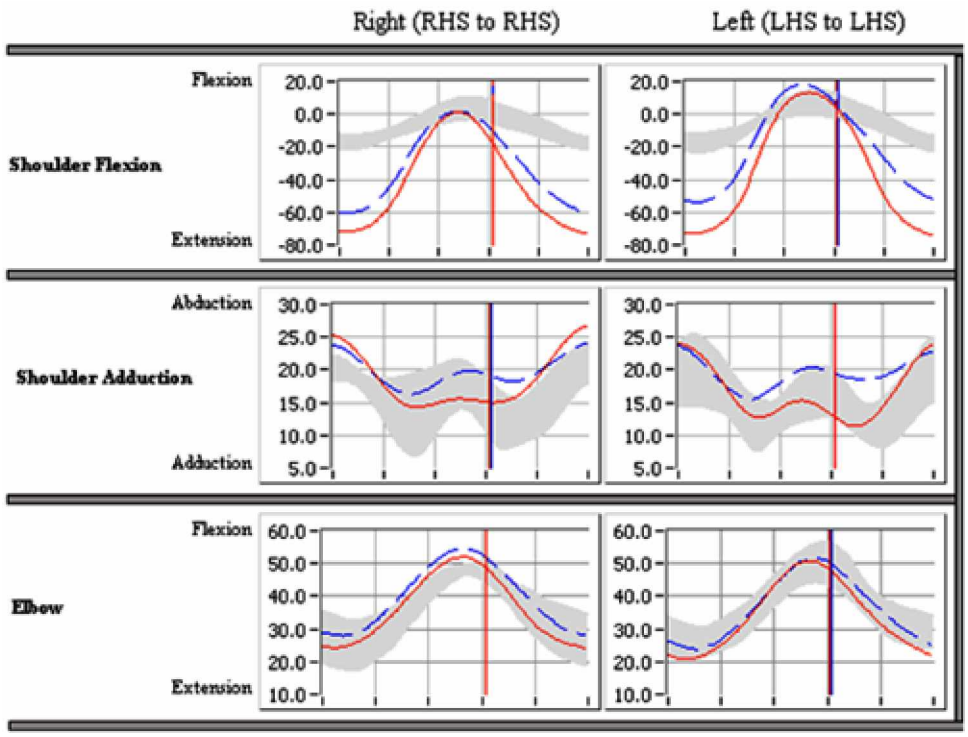

Figure B.53 Arm Joint Angles (Degrees), 20-year-old subjects.

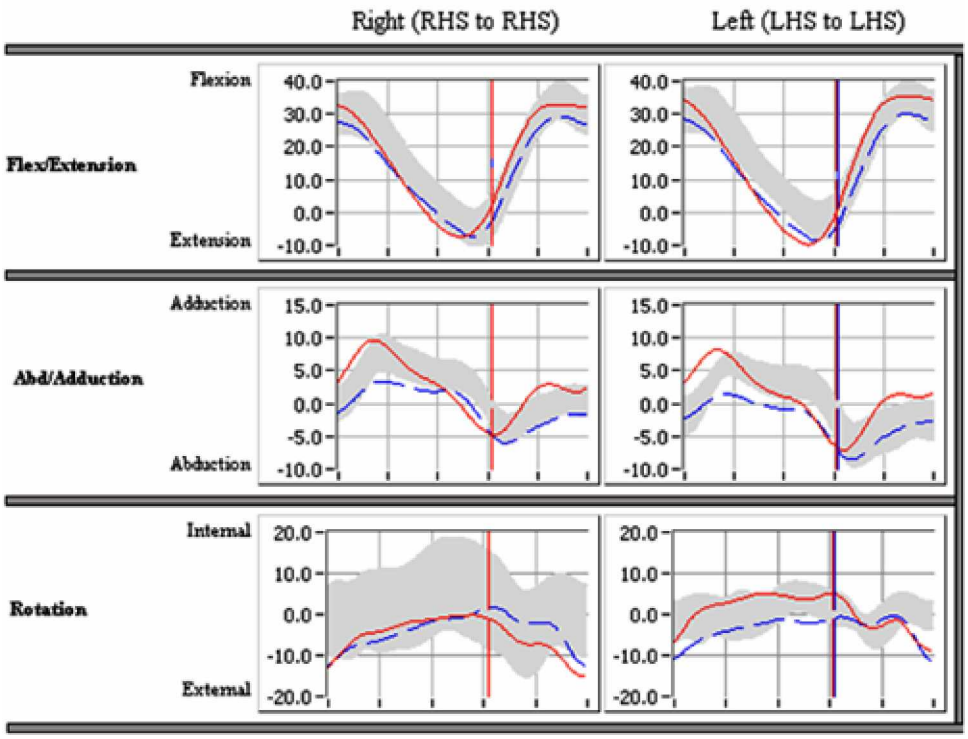

Figure B.54 Hip Joint Angles (Degrees), 20-year-old subjects.

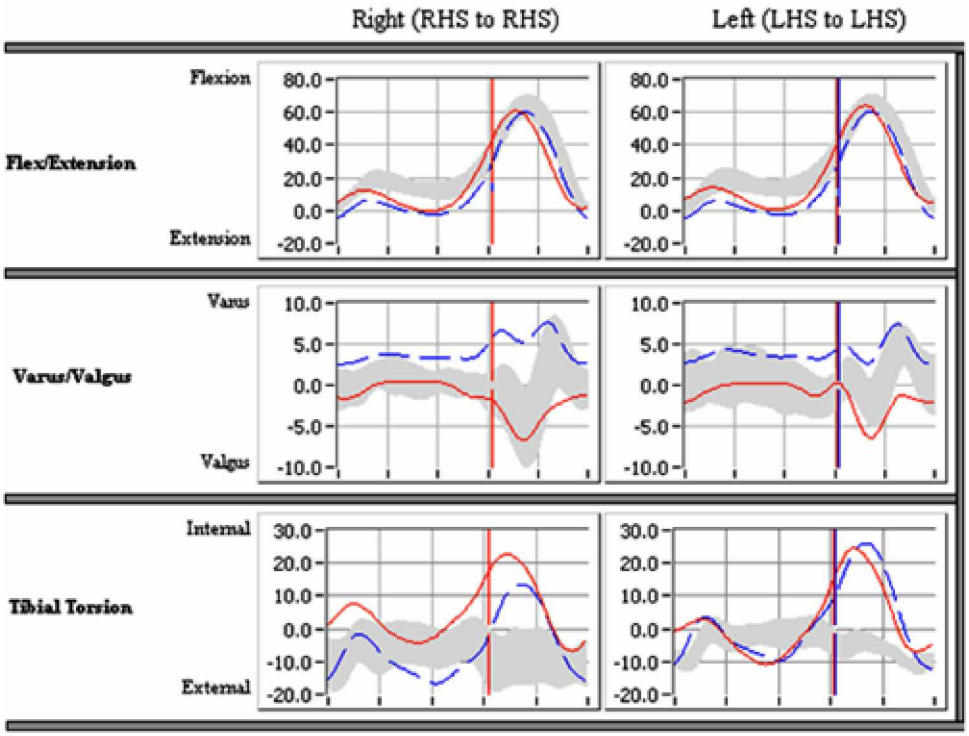

Figure B.55 Knee Joint Angles (Degrees), 20-year-old subjects.

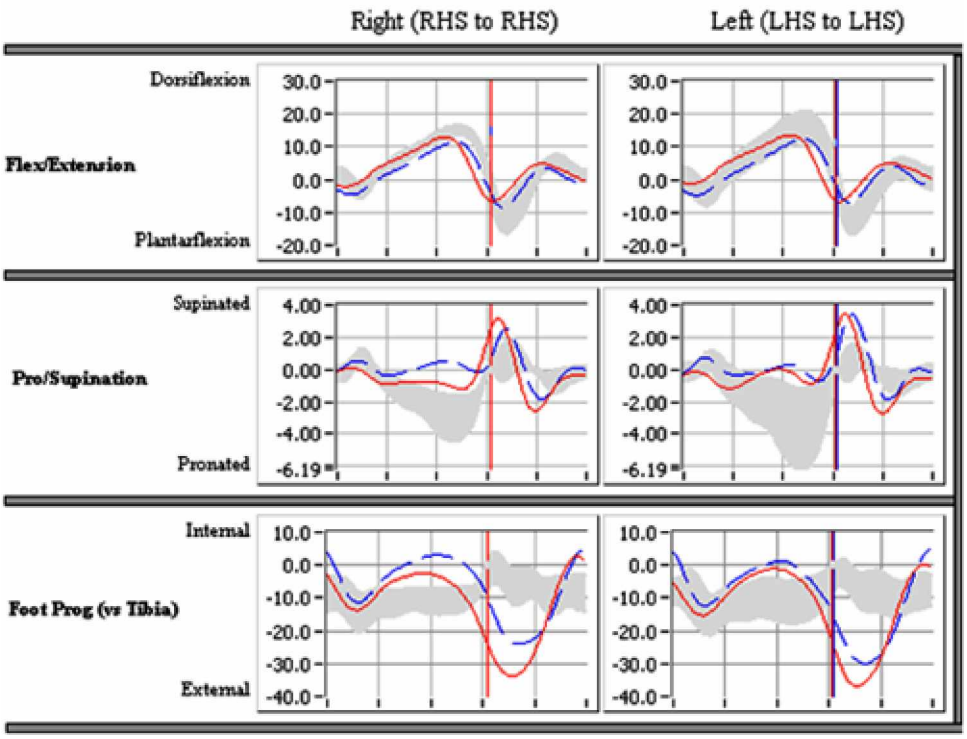

Figure B.56 Ankle Joint Angles (Degrees), 20-year-old subjects.

APPENDIX C

KINETICS

In this section, kinetic data of subjects were presented in the tables and as graphs. Curves of females and males were shown in the same graph with a normal band, representing system's current normative data, with one standard deviation.

For better understanding of the tables, it is useful to state that:

St. = Stance, Sw. = Swing, Max. = Maximum, Min. = Minimum, SD = One Standard Deviation, R = Right, L = Left, Rot = Rotation, Abd = Abduction, Flex = Flexion, Ank = Ankle, Shl = Shoulder, Lat = Lateral, Vrt = Vertical, Fwd = Forward, Frc = Force, GRF = Ground Reaction Force, Mom = Moment, Pwr = Power.

For better understanding of the figures, it is useful to state that:

- x-axis represents 0-100 % of the gait cycle.
- The gray bands represent norm data of Orthotrak software (Motion Analysis Corp.) with one standard deviation.
- RHS = Right Heel Strike and LHS = Left Heel Strike.

Table C.1 Stance Phase Kinetics of 5-year-old Female Subjects.

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	0.13	0.04	1.12	0.10	18.33	9.81	0.08	0.08	28.11	31.50
L_Hip_Rot_Frc	0.17	0.03	1.12	0.11	14.44	0.83	0.09	0.09	47.78	25.68
R_Hip_Abd_Frc	-0.07	0.02	0.27	0.07	47.00	1.70	-0.22	0.07	11.11	1.52
L_Hip_Abd_Frc	-0.07	0.02	0.27	0.07	46.44	1.57	-0.21	0.08	10.11	1.45
R_Hip_Flex_Frc	0.01	0.01	0.15	0.03	34.33	12.94	0.00	0.01	39.22	34.21
L_Hip_Flex_Frc	0.01	0.01	0.14	0.03	32.89	11.09	0.00	0.01	49.00	26.28
R_Knee_Rot_Frc	0.20	0.04	1.18	0.10	14.44	0.83	0.12	0.07	48.33	25.98
L_Knee_Rot_Frc	0.24	0.03	1.17	0.10	13.67	0.67	0.12	0.08	60.89	2.73
R_Knee_Abd_Frc	-0.05	0.02	0.36	0.05	50.22	1.75	-0.07	0.03	2.22	1.55
L_Knee_Abd_Frc	-0.07	0.02	0.34	0.05	49.67	1.05	-0.08	0.03	2.33	1.33
R_Knee_Flex_Frc	-0.01	0.01	0.20	0.05	20.67	8.67	-0.01	0.01	15.00	27.10
L_Knee_Flex_Frc	-0.01	0.01	0.20	0.07	17.44	0.83	-0.02	0.02	15.22	26.97
R_Ank_Rot_Frc	0.22	0.04	1.23	0.10	21.78	12.97	0.15	0.08	48.11	25.93
L_Ank_Rot_Frc	0.26	0.03	1.22	0.11	17.56	9.38	0.15	0.08	61.00	3.02
R_Ank_Abd_Frc	-0.08	0.02	0.21	0.04	55.33	1.56	-0.12	0.03	4.22	0.63
L_Ank_Abd_Frc	-0.09	0.02	0.21	0.04	54.67	1.25	-0.12	0.02	3.44	0.83
R_Ank_Flex_Frc	0.00	0.01	0.08	0.02	29.67	12.09	-0.02	0.01	53.33	15.36
L_Ank_Flex_Frc	0.00	0.01	0.09	0.03	24.22	8.90	-0.01	0.01	39.22	27.78
R_GRF_Fwd_Frc	-0.01	0.04	0.21	0.03	53.56	0.83	-0.21	0.03	10.33	1.05
L_GRF_Fwd_Frc	0.00	0.00	0.22	0.03	53.33	0.94	-0.20	0.04	9.67	0.82
R_GRF_Lat_Frc	0.00	0.00	0.07	0.02	43.44	12.35	-0.03	0.02	9.78	17.78
L_GRF_Lat_Frc	0.00	0.00	0.08	0.02	19.33	11.19	-0.01	0.01	8.89	18.15
R_GRF_Vrt_Frc	0.02	0.05	1.29	0.12	14.67	0.82	0.01	0.04	6.67	18.87
L_GRF_Vrt_Frc	0.00	0.00	1.28	0.13	14.00	0.82	0.00	0.00	0.00	0.00
R_Hip_Rot_Mom	-0.02	0.01	0.08	0.05	17.11	14.59	-0.12	0.03	41.11	12.73
L_Hip_Rot_Mom	0.00	0.02	0.12	0.07	13.22	1.93	-0.15	0.05	45.78	3.59
R_Hip_Abd_Mom	0.02	0.07	0.52	0.12	21.56	8.07	-0.03	0.03	28.00	31.36
L_Hip_Abd_Mom	0.01	0.06	0.53	0.12	24.89	10.84	-0.02	0.04	20.22	28.62
R_Hip_Flex_Mom	0.36	0.07	0.52	0.16	6.22	1.75	-0.50	0.10	50.56	1.50
L_Hip_Flex_Mom	0.38	0.08	0.54	0.13	6.00	0.94	-0.47	0.10	49.33	0.82
R_Knee_Rot_Mom	-0.01	0.01	0.04	0.04	20.67	21.10	-0.14	0.03	35.11	17.47
L_Knee_Rot_Mom	0.01	0.02	0.08	0.07	10.00	3.16	-0.14	0.05	46.78	3.55
R_Knee_Abd_Mom	-0.03	0.03	0.27	0.08	16.56	1.42	-0.03	0.02	12.33	23.23
L_Knee_Abd_Mom	-0.03	0.03	0.28	0.11	23.22	12.91	-0.04	0.03	6.89	18.12
R_Knee_Flex_Mom	-0.15	0.04	0.20	0.08	44.11	20.63	-0.28	0.10	40.67	3.09
L_Knee_Flex_Mom	-0.16	0.03	0.14	0.04	48.33	18.38	-0.29	0.12	30.56	16.63
R_Ank_Rot_Mom	0.01	0.01	0.13	0.03	38.67	14.54	-0.05	0.04	20.67	20.87
L_Ank_Rot_Mom	-0.01	0.02	0.14	0.05	45.89	4.07	-0.08	0.07	10.44	3.47
R_Ank_Abd_Mom	0.01	0.01	0.07	0.04	37.44	17.05	-0.02	0.02	28.00	6.15
L_Ank_Abd_Mom	0.00	0.01	0.06	0.04	36.33	19.22	-0.04	0.04	17.78	10.65
R_Ank_Flex_Mom	0.03	0.01	1.02	0.10	46.33	2.45	0.01	0.02	10.33	20.80
L_Ank_Flex_Mom	0.02	0.01	1.00	0.10	45.67	1.33	0.00	0.03	9.78	20.29
R_Hip_Pwr	0.29	0.31	0.76	0.25	21.00	20.89	-0.83	0.25	46.00	1.41
L_Hip_Pwr	0.25	0.26	0.81	0.19	9.67	3.40	-0.75	0.24	45.11	1.37
R_Knee_Pwr	-0.10	0.21	0.44	0.26	27.33	19.11	-1.16	0.37	59.44	1.26
L_Knee_Pwr	-0.01	0.19	0.44	0.25	27.56	22.47	-0.99	0.24	58.89	0.74
R_Ank_Pwr	0.02	0.01	1.98	0.38	52.44	1.42	-0.50	0.22	28.44	10.66
L_Ank_Pwr	0.02	0.01	1.99	0.35	51.78	1.32	-0.50	0.15	24.89	9.27

Table C.2 Swing Phase Kinetics of 5-year-old Female Subjects.

	Maximum Swing		Time of Max. Sw.		Minimum Swing		Time of Min. Sw.		Toe Off	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	0.06	0.06	60.61	1.52	-0.10	0.03	74.38	13.81	0.06	0.06
L_Hip_Rot_Frc	0.05	0.04	60.38	1.58	-0.10	0.04	80.94	16.79	0.05	0.04
R_Hip_Abd_Frc	0.03	0.02	64.94	8.78	0.00	0.01	93.61	11.55	0.02	0.02
L_Hip_Abd_Frc	0.02	0.01	66.60	8.86	0.00	0.01	95.49	7.28	0.01	0.01
R_Hip_Flex_Frc	0.01	0.01	68.16	13.28	0.00	0.00	82.49	13.79	0.00	0.01
L_Hip_Flex_Frc	0.01	0.00	68.05	10.64	0.00	0.00	71.83	12.61	0.00	0.00
R_Knee_Rot_Frc	0.09	0.06	60.61	1.52	-0.04	0.02	80.94	15.65	0.09	0.06
L_Knee_Rot_Frc	0.08	0.04	60.38	1.58	-0.04	0.02	83.16	15.29	0.08	0.04
R_Knee_Abd_Frc	0.08	0.04	60.61	1.52	-0.03	0.01	93.61	1.94	0.08	0.04
L_Knee_Abd_Frc	0.06	0.03	60.38	1.58	-0.03	0.01	93.71	2.37	0.06	0.03
R_Knee_Flex_Frc	0.02	0.02	64.83	12.38	-0.01	0.01	68.83	1.73	0.02	0.02
L_Knee_Flex_Frc	0.02	0.02	64.38	12.19	-0.02	0.01	70.27	6.93	0.02	0.02
R_Ank_Rot_Frc	0.12	0.07	60.61	1.52	-0.03	0.01	72.38	9.20	0.12	0.07
L_Ank_Rot_Frc	0.11	0.05	60.38	1.58	-0.03	0.01	68.38	1.10	0.11	0.05
R_Ank_Abd_Frc	0.08	0.05	60.61	1.52	-0.01	0.01	80.49	14.18	0.08	0.05
L_Ank_Abd_Frc	0.07	0.03	60.38	1.58	-0.01	0.01	80.05	15.05	0.07	0.03
R_Ank_Flex_Frc	0.00	0.00	87.05	12.94	-0.01	0.01	61.83	2.29	-0.01	0.01
L_Ank_Flex_Frc	0.00	0.00	83.94	13.74	-0.01	0.01	61.60	1.94	-0.01	0.01
R_GRF_Fwd_Frc	0.04	0.03	60.61	1.52	0.00	0.00	64.49	1.46	0.04	0.03
L_GRF_Fwd_Frc	0.03	0.02	60.38	1.58	0.00	0.00	63.94	2.70	0.03	0.02
R_GRF_Lat_Frc	0.00	0.00	64.38	4.64	0.00	0.00	61.61	2.01	0.00	0.00
L_GRF_Lat_Frc	0.00	0.00	63.83	2.82	0.00	0.00	61.38	1.86	0.00	0.00
R_GRF_Vrt_Frc	0.10	0.07	60.94	2.19	0.00	0.00	65.94	4.59	0.10	0.07
L_GRF_Vrt_Frc	0.09	0.06	60.71	1.91	0.00	0.00	64.05	2.70	0.09	0.06
R_Hip_Rot_Mom	0.01	0.01	68.05	9.75	-0.01	0.01	77.38	15.85	0.00	0.02
L_Hip_Rot_Mom	0.01	0.00	68.38	11.60	-0.01	0.02	69.38	1.40	-0.01	0.02
R_Hip_Abd_Mom	0.04	0.04	71.16	16.38	-0.02	0.02	75.94	14.17	0.02	0.05
L_Hip_Abd_Mom	0.02	0.02	75.16	15.45	-0.02	0.01	75.49	14.80	0.01	0.03
R_Hip_Flex_Mom	0.09	0.04	97.38	1.19	-0.19	0.10	60.61	1.52	-0.19	0.10
L_Hip_Flex_Mom	0.07	0.03	97.83	1.30	-0.14	0.07	60.38	1.58	-0.14	0.07
R_Knee_Rot_Mom	0.01	0.00	66.27	6.37	-0.01	0.01	72.16	14.90	0.00	0.01
L_Knee_Rot_Mom	0.01	0.00	64.49	4.46	-0.01	0.02	71.94	16.06	-0.01	0.02
R_Knee_Abd_Mom	0.03	0.02	70.94	16.45	-0.02	0.01	80.16	11.44	0.02	0.02
L_Knee_Abd_Mom	0.04	0.03	60.38	1.58	-0.02	0.01	69.05	1.52	0.03	0.04
R_Knee_Flex_Mom	0.10	0.04	60.72	1.47	-0.06	0.02	95.83	1.39	0.10	0.04
L_Knee_Flex_Mom	0.09	0.04	60.38	1.58	-0.04	0.01	93.60	3.77	0.09	0.04
R_Ank_Rot_Mom	0.01	0.01	70.83	14.07	-0.01	0.00	65.94	6.47	0.00	0.01
L_Ank_Rot_Mom	0.01	0.02	71.83	13.97	-0.01	0.00	64.27	4.06	0.01	0.02
R_Ank_Abd_Mom	0.01	0.01	64.27	11.47	0.00	0.00	68.61	5.84	0.01	0.01
L_Ank_Abd_Mom	0.01	0.01	60.38	1.58	0.00	0.00	68.60	3.40	0.01	0.01
R_Ank_Flex_Mom	0.10	0.06	60.61	1.52	-0.02	0.01	68.94	3.58	0.10	0.06
L_Ank_Flex_Mom	0.09	0.04	60.38	1.58	-0.02	0.01	67.71	2.09	0.09	0.04
R_Hip_Pwr	0.46	0.26	61.05	1.75	-0.05	0.06	85.38	1.65	0.45	0.25
L_Hip_Pwr	0.34	0.19	61.71	4.38	-0.04	0.03	84.60	7.60	0.34	0.19
R_Knee_Pwr	0.09	0.05	70.27	2.41	-0.84	0.40	60.94	1.67	-0.84	0.40
L_Knee_Pwr	0.08	0.04	68.71	1.28	-0.70	0.35	60.38	1.58	-0.70	0.35
R_Ank_Pwr	0.20	0.13	60.61	1.52	0.00	0.00	86.72	8.32	0.20	0.13
L_Ank_Pwr	0.17	0.11	60.38	1.58	0.00	0.00	88.49	10.28	0.17	0.11

Table C.3 Stance Phase Kinetics of 5-year-old Male Subjects.

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	0.13	0.04	1.12	0.11	18.44	10.36	0.09	0.08	28.22	33.54
L_Hip_Rot_Frc	0.17	0.03	1.12	0.11	14.44	0.88	0.11	0.09	27.89	33.15
R_Hip_Abd_Frc	-0.07	0.02	0.27	0.08	47.33	1.50	-0.22	0.07	11.22	1.64
L_Hip_Abd_Frc	-0.07	0.02	0.27	0.08	46.56	1.51	-0.21	0.08	10.67	1.58
R_Hip_Flex_Frc	0.01	0.01	0.15	0.03	34.56	13.46	0.00	0.01	29.56	32.29
L_Hip_Flex_Frc	0.01	0.01	0.14	0.03	33.00	12.06	0.00	0.01	48.89	27.39
R_Knee_Rot_Frc	0.20	0.04	1.17	0.11	14.56	0.88	0.14	0.08	28.22	33.54
L_Knee_Rot_Frc	0.24	0.04	1.17	0.11	13.78	0.67	0.15	0.09	47.89	27.32
R_Knee_Abd_Frc	-0.05	0.02	0.36	0.05	50.56	2.07	-0.07	0.03	2.22	1.64
L_Knee_Abd_Frc	-0.07	0.02	0.34	0.05	50.11	0.93	-0.08	0.03	2.33	1.41
R_Knee_Flex_Frc	-0.01	0.01	0.20	0.06	20.89	9.12	-0.01	0.01	15.00	28.73
L_Knee_Flex_Frc	-0.01	0.01	0.20	0.07	17.89	0.93	-0.01	0.02	15.33	28.83
R_Ank_Rot_Frc	0.22	0.04	1.23	0.11	22.00	13.91	0.17	0.08	28.44	33.85
L_Ank_Rot_Frc	0.26	0.04	1.22	0.12	17.78	10.23	0.19	0.10	48.00	27.41
R_Ank_Abd_Frc	-0.08	0.02	0.21	0.04	55.89	1.96	-0.12	0.03	4.22	0.67
L_Ank_Abd_Frc	-0.09	0.02	0.21	0.04	55.56	1.42	-0.12	0.02	3.89	0.78
R_Ank_Flex_Frc	0.00	0.01	0.08	0.02	29.78	12.64	-0.02	0.01	53.78	16.47
L_Ank_Flex_Frc	0.00	0.01	0.09	0.03	24.56	9.19	-0.01	0.01	39.44	29.61
R_GRF_Fwd_Frc	-0.01	0.04	0.21	0.03	54.11	0.93	-0.21	0.04	10.67	1.32
L_GRF_Fwd_Frc	0.00	0.00	0.22	0.03	54.00	1.00	-0.20	0.04	10.11	1.36
R_GRF_Lat_Frc	0.00	0.00	0.07	0.02	43.89	13.35	-0.03	0.02	9.89	18.80
L_GRF_Lat_Frc	0.00	0.00	0.08	0.02	19.67	12.11	-0.01	0.01	8.89	19.24
R_GRF_Vrt_Frc	0.02	0.06	1.29	0.13	14.67	0.87	0.02	0.05	6.67	20.00
L_GRF_Vrt_Frc	0.00	0.00	1.28	0.13	14.11	1.05	0.00	0.00	0.00	0.00
R_Hip_Rot_Mom	-0.02	0.01	0.08	0.05	17.56	15.69	-0.12	0.04	41.56	13.33
L_Hip_Rot_Mom	0.00	0.02	0.12	0.07	13.44	2.13	-0.15	0.06	46.22	3.96
R_Hip_Abd_Mom	0.02	0.07	0.52	0.12	21.78	8.89	-0.03	0.04	28.11	33.39
L_Hip_Abd_Mom	0.01	0.06	0.53	0.13	25.00	11.70	-0.01	0.05	13.67	27.12
R_Hip_Flex_Mom	0.36	0.07	0.52	0.17	6.22	1.86	-0.50	0.10	50.89	1.83
L_Hip_Flex_Mom	0.38	0.08	0.53	0.13	6.00	1.00	-0.47	0.11	49.89	1.17
R_Knee_Rot_Mom	-0.01	0.01	0.04	0.04	20.67	22.37	-0.14	0.04	35.33	18.43
L_Knee_Rot_Mom	0.01	0.02	0.07	0.08	9.89	3.72	-0.14	0.06	47.00	3.67
R_Knee_Abd_Mom	-0.03	0.03	0.27	0.08	16.78	1.30	-0.03	0.02	12.33	24.63
L_Knee_Abd_Mom	-0.03	0.03	0.28	0.12	23.67	13.99	-0.04	0.03	6.89	19.21
R_Knee_Flex_Mom	-0.15	0.04	0.19	0.08	44.33	22.03	-0.28	0.11	41.11	3.69
L_Knee_Flex_Mom	-0.16	0.04	0.14	0.04	48.89	19.80	-0.29	0.13	30.89	17.84
R_Ank_Rot_Mom	0.01	0.01	0.13	0.03	38.89	15.57	-0.05	0.04	20.67	22.12
L_Ank_Rot_Mom	-0.01	0.02	0.14	0.06	46.00	4.33	-0.08	0.07	10.56	3.47
R_Ank_Abd_Mom	0.01	0.01	0.07	0.04	37.56	17.76	-0.02	0.02	28.33	6.63
L_Ank_Abd_Mom	0.00	0.01	0.06	0.04	36.56	20.56	-0.04	0.04	17.89	11.35
R_Ank_Flex_Mom	0.03	0.01	1.01	0.11	46.78	2.77	0.01	0.03	10.11	22.16
L_Ank_Flex_Mom	0.02	0.02	1.00	0.11	46.33	1.87	0.00	0.03	9.89	21.84
R_Hip_Pwr	0.29	0.33	0.76	0.26	21.22	22.29	-0.83	0.27	46.33	1.80
L_Hip_Pwr	0.25	0.28	0.81	0.21	9.89	3.86	-0.75	0.26	45.56	1.42
R_Knee_Pwr	-0.10	0.22	0.44	0.27	27.78	20.46	-1.13	0.39	59.89	1.36
L_Knee_Pwr	-0.01	0.20	0.44	0.26	27.78	23.79	-0.97	0.26	59.33	0.87
R_Ank_Pwr	0.02	0.01	1.97	0.40	52.89	1.54	-0.50	0.23	28.78	11.48
L_Ank_Pwr	0.02	0.01	1.98	0.37	52.22	1.56	-0.49	0.16	25.00	10.00

Table C.4 Swing Phase Kinetics of 5-year-old Male Subjects.

	Maximum Swing		Time of Max. Sw.		Minimum Swing		Time of Min. Sw.		Toe Off	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	0.10	0.07	60.94	1.60	-0.10	0.04	67.83	1.31	0.10	0.07
L_Hip_Rot_Frc	0.08	0.06	60.61	1.13	-0.10	0.04	67.05	0.73	0.08	0.06
R_Hip_Abd_Frc	0.03	0.02	70.72	13.24	0.00	0.01	86.83	12.95	0.03	0.03
L_Hip_Abd_Frc	0.02	0.01	69.05	9.97	0.00	0.01	87.94	16.46	0.02	0.02
R_Hip_Flex_Frc	0.01	0.01	74.50	11.77	0.00	0.00	83.05	15.52	0.01	0.01
L_Hip_Flex_Frc	0.01	0.00	75.27	12.67	0.00	0.00	72.27	12.65	0.00	0.01
R_Knee_Rot_Frc	0.12	0.08	60.94	1.60	-0.04	0.02	67.94	1.51	0.12	0.08
L_Knee_Rot_Frc	0.11	0.06	60.61	1.13	-0.04	0.02	73.05	11.98	0.11	0.06
R_Knee_Abd_Frc	0.09	0.05	60.94	1.60	-0.03	0.01	93.72	2.26	0.09	0.05
L_Knee_Abd_Frc	0.08	0.04	60.61	1.13	-0.03	0.01	93.94	1.50	0.08	0.04
R_Knee_Flex_Frc	0.03	0.02	64.83	12.02	-0.01	0.01	72.50	8.05	0.02	0.02
L_Knee_Flex_Frc	0.03	0.02	64.38	12.12	-0.02	0.01	67.83	0.83	0.03	0.02
R_Ank_Rot_Frc	0.15	0.08	60.94	1.60	-0.03	0.01	69.16	1.13	0.15	0.08
L_Ank_Rot_Frc	0.14	0.07	60.61	1.13	-0.03	0.01	68.27	0.71	0.14	0.07
R_Ank_Abd_Frc	0.10	0.05	60.94	1.60	-0.01	0.01	76.61	13.35	0.10	0.05
L_Ank_Abd_Frc	0.09	0.04	60.61	1.13	-0.01	0.01	73.72	12.16	0.09	0.04
R_Ank_Flex_Frc	0.00	0.00	85.72	10.01	-0.01	0.01	61.05	1.35	-0.01	0.01
L_Ank_Flex_Frc	0.00	0.00	81.16	12.07	-0.01	0.01	63.49	5.01	-0.01	0.01
R_GRF_Fwd_Frc	0.05	0.03	61.50	2.04	0.00	0.00	63.72	1.18	0.05	0.03
L_GRF_Fwd_Frc	0.04	0.02	60.61	1.13	0.00	0.00	63.38	1.57	0.04	0.02
R_GRF_Lat_Frc	0.00	0.00	62.05	2.26	0.00	0.00	63.05	1.59	0.00	0.00
L_GRF_Lat_Frc	0.00	0.00	62.83	2.34	0.00	0.00	61.49	1.37	0.00	0.00
R_GRF_Vrt_Frc	0.13	0.08	61.16	1.44	0.00	0.00	64.39	1.21	0.13	0.08
L_GRF_Vrt_Frc	0.11	0.06	60.61	1.13	0.00	0.00	63.61	1.74	0.11	0.06
R_Hip_Rot_Mom	0.01	0.01	73.16	10.69	-0.01	0.01	67.94	11.28	-0.01	0.02
L_Hip_Rot_Mom	0.01	0.01	72.83	12.06	-0.02	0.02	69.27	11.30	-0.01	0.03
R_Hip_Abd_Mom	0.04	0.05	76.61	19.53	-0.02	0.02	73.28	13.96	0.02	0.06
L_Hip_Abd_Mom	0.03	0.03	74.16	13.63	-0.02	0.01	71.61	14.87	0.02	0.04
R_Hip_Flex_Mom	0.09	0.05	96.83	1.92	-0.21	0.12	60.94	1.60	-0.21	0.12
L_Hip_Flex_Mom	0.07	0.03	98.16	1.01	-0.16	0.09	60.61	1.13	-0.16	0.09
R_Knee_Rot_Mom	0.01	0.00	65.05	3.28	-0.01	0.01	72.72	13.92	-0.01	0.02
L_Knee_Rot_Mom	0.01	0.00	64.94	2.12	-0.02	0.02	67.72	14.44	-0.01	0.02
R_Knee_Abd_Mom	0.03	0.02	65.05	12.68	-0.02	0.01	75.72	11.04	0.03	0.03
L_Knee_Abd_Mom	0.04	0.04	64.05	10.74	-0.02	0.01	69.49	5.70	0.04	0.04
R_Knee_Flex_Mom	0.11	0.04	60.94	1.60	-0.06	0.02	95.39	1.30	0.11	0.04
L_Knee_Flex_Mom	0.09	0.04	60.61	1.13	-0.04	0.01	93.05	4.04	0.09	0.04
R_Ank_Rot_Mom	0.01	0.01	72.61	13.66	-0.01	0.01	64.83	2.82	0.01	0.02
L_Ank_Rot_Mom	0.02	0.02	68.05	15.10	-0.01	0.00	64.72	1.96	0.01	0.02
R_Ank_Abd_Mom	0.01	0.01	64.72	10.88	0.00	0.00	65.94	3.75	0.01	0.02
L_Ank_Abd_Mom	0.01	0.01	67.83	14.46	0.00	0.00	66.49	2.20	0.01	0.02
R_Ank_Flex_Mom	0.13	0.08	60.94	1.60	-0.02	0.01	67.83	1.31	0.13	0.08
L_Ank_Flex_Mom	0.12	0.06	60.61	1.13	-0.02	0.01	67.27	0.71	0.12	0.06
R_Hip_Pwr	0.47	0.28	61.16	1.61	-0.05	0.07	86.39	2.05	0.46	0.26
L_Hip_Pwr	0.36	0.21	60.61	1.13	-0.04	0.04	87.05	4.80	0.36	0.21
R_Knee_Pwr	0.08	0.05	70.28	3.16	-0.88	0.43	61.05	1.52	-0.87	0.42
L_Knee_Pwr	0.08	0.05	68.72	0.93	-0.75	0.37	60.61	1.13	-0.75	0.37
R_Ank_Pwr	0.29	0.18	60.94	1.60	0.00	0.00	93.83	3.15	0.29	0.18
L_Ank_Pwr	0.25	0.15	61.38	2.59	0.00	0.00	88.83	11.03	0.25	0.15

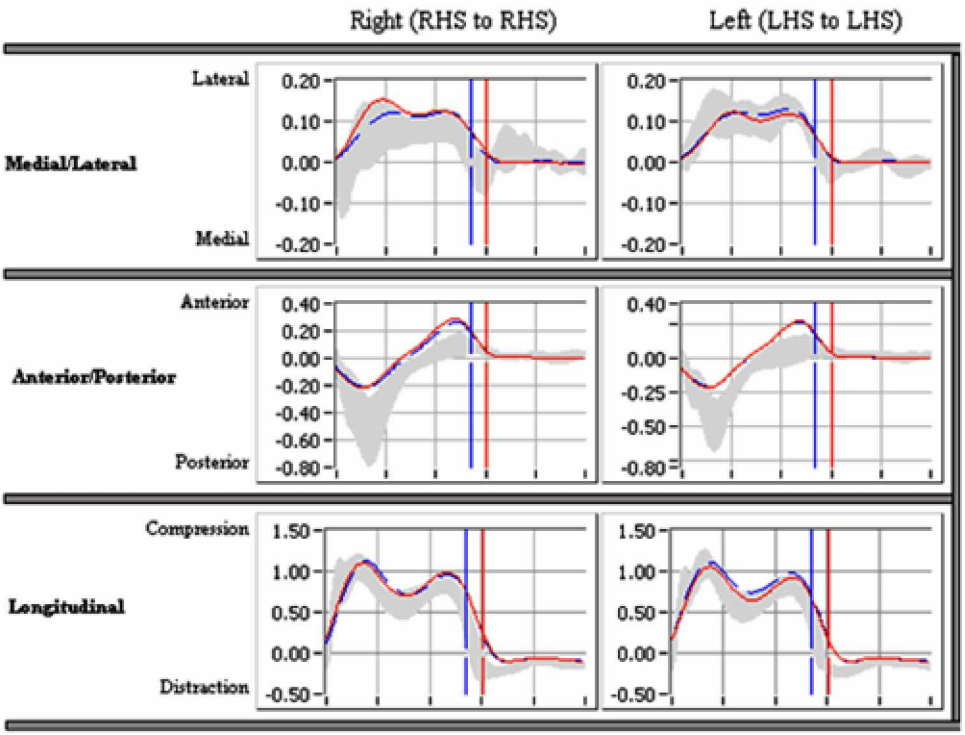

Figure C.1 Hip Joint Forces (N), 5-year-old subjects.

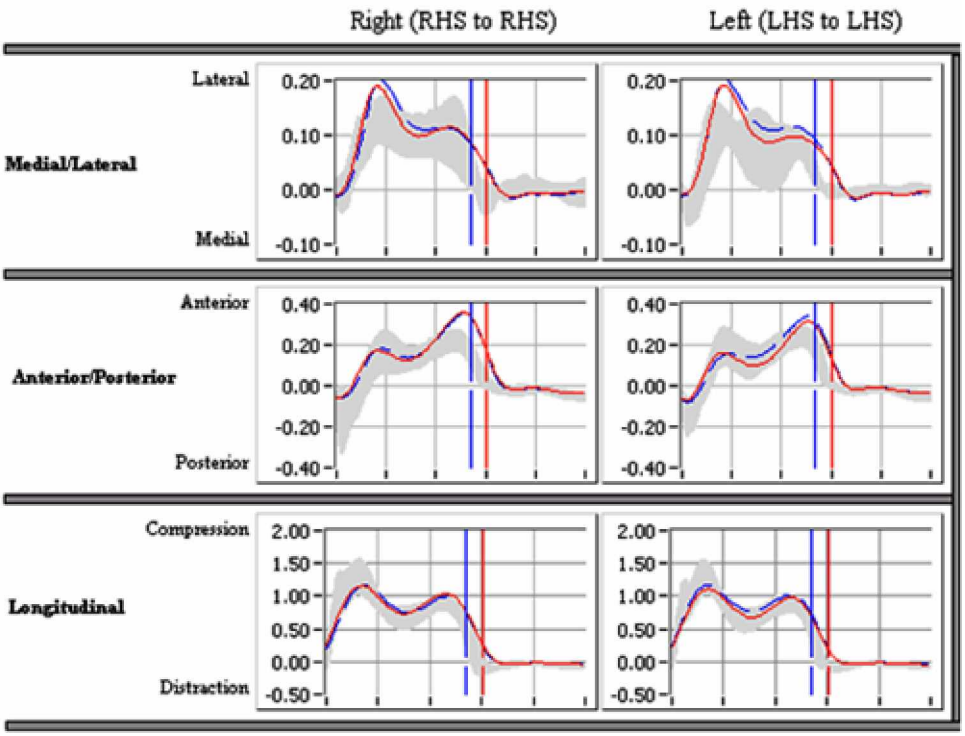

Figure C.2 Knee Joint Forces (N), 5-year-old subjects.

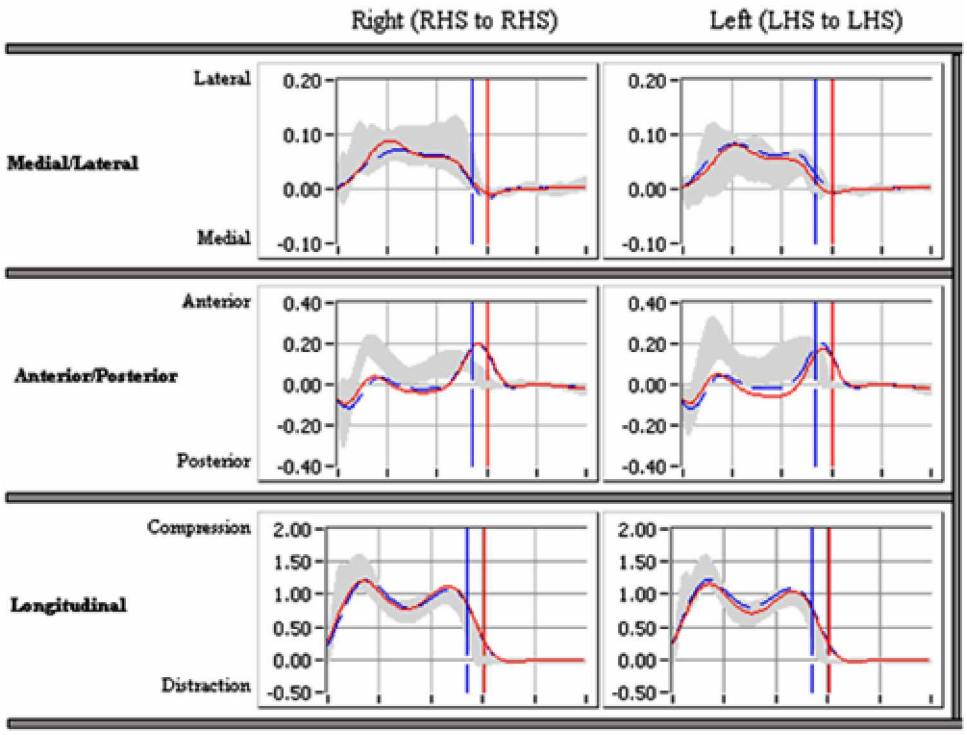

Figure C.3 Ankle Joint Forces (N), 5-year-old subjects.

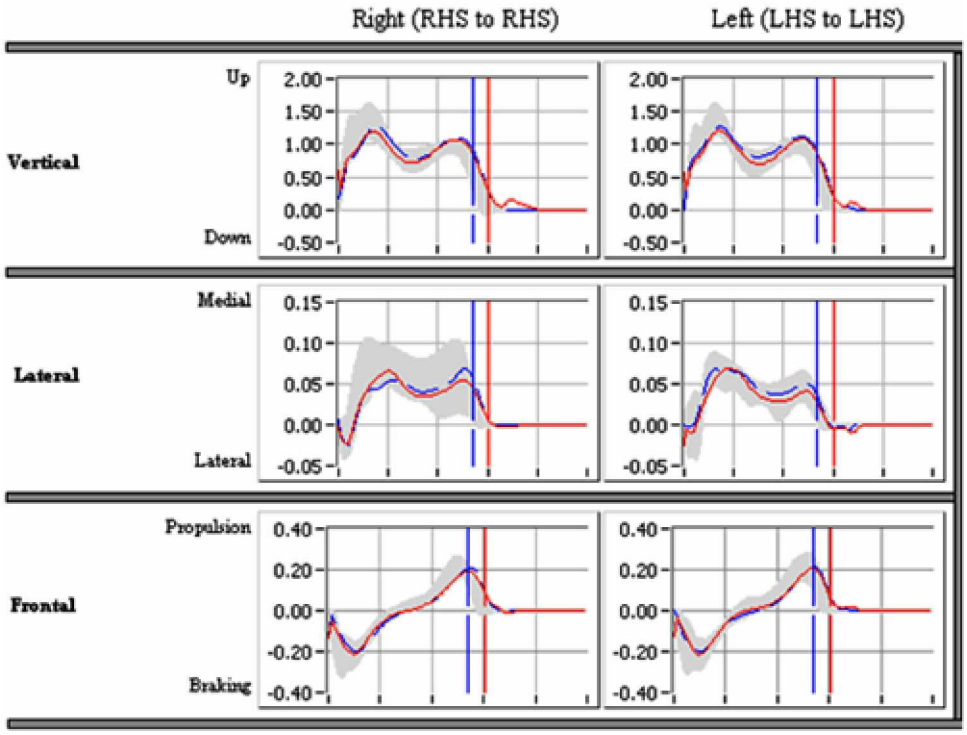

Figure C.4 Ground Reaction Forces (N), 5-year-old subjects.

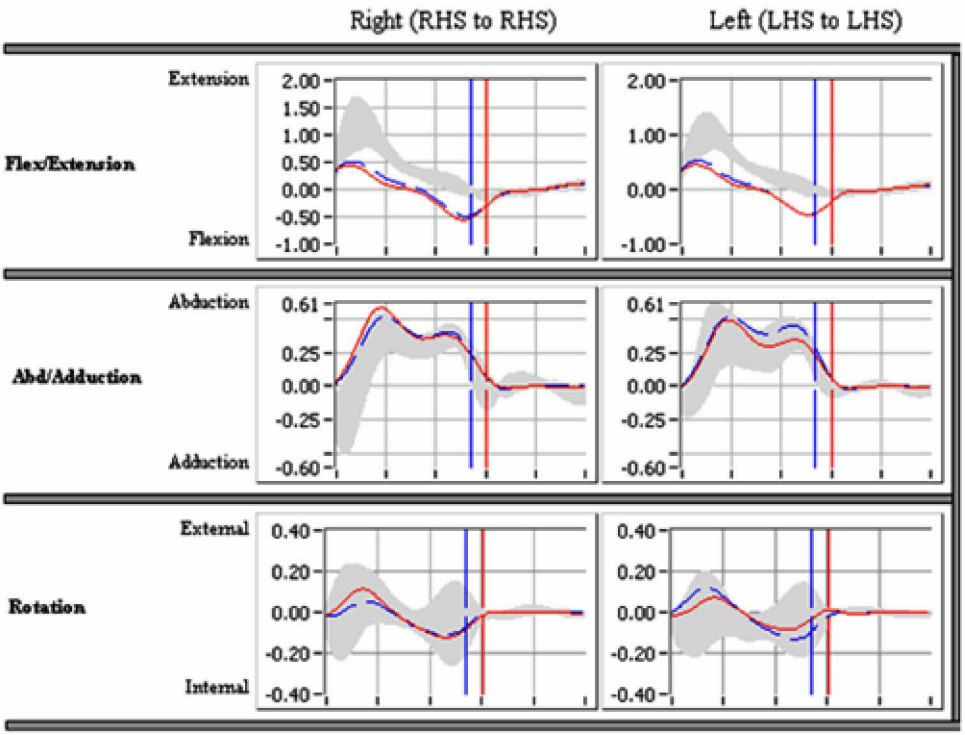

Figure C.5 Hip Joint Moments (Nm/Kg), 5-year-old subjects.

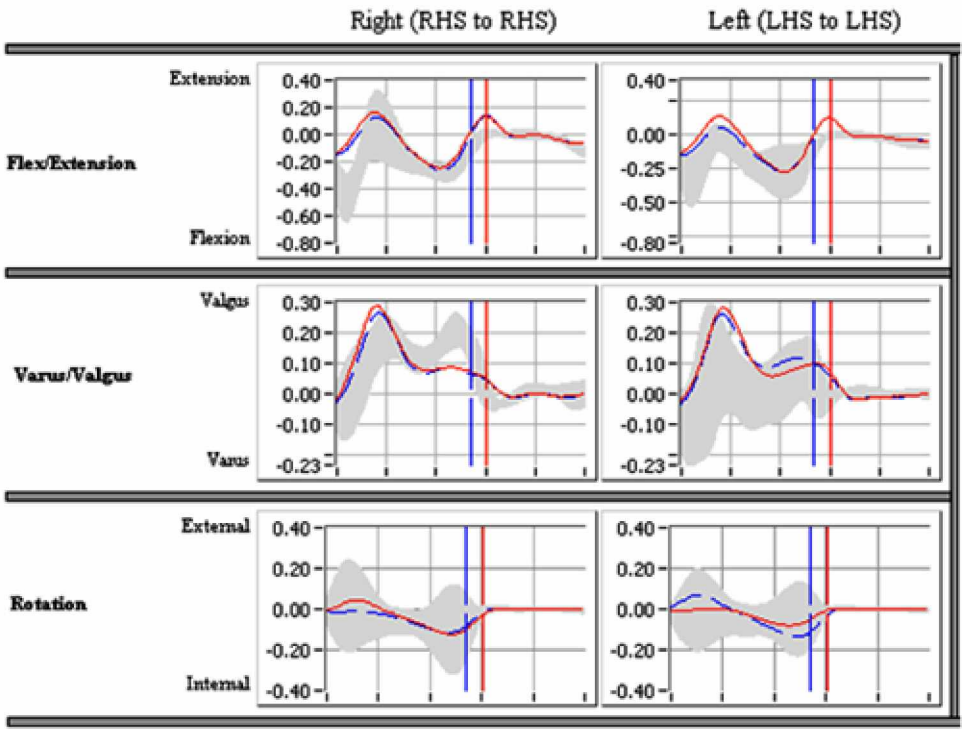

Figure C.6 Knee Joint Moments (Nm/Kg), 5-year-old subjects.

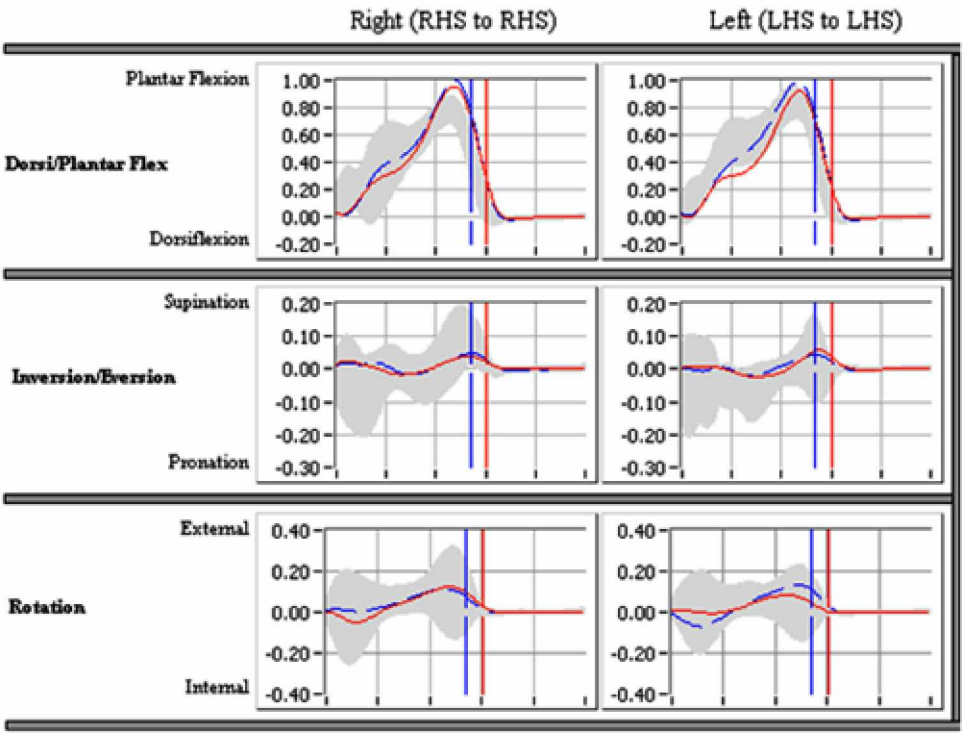

Figure C.7 Ankle Joint Moments (Nm/Kg), 5-year-old subjects.

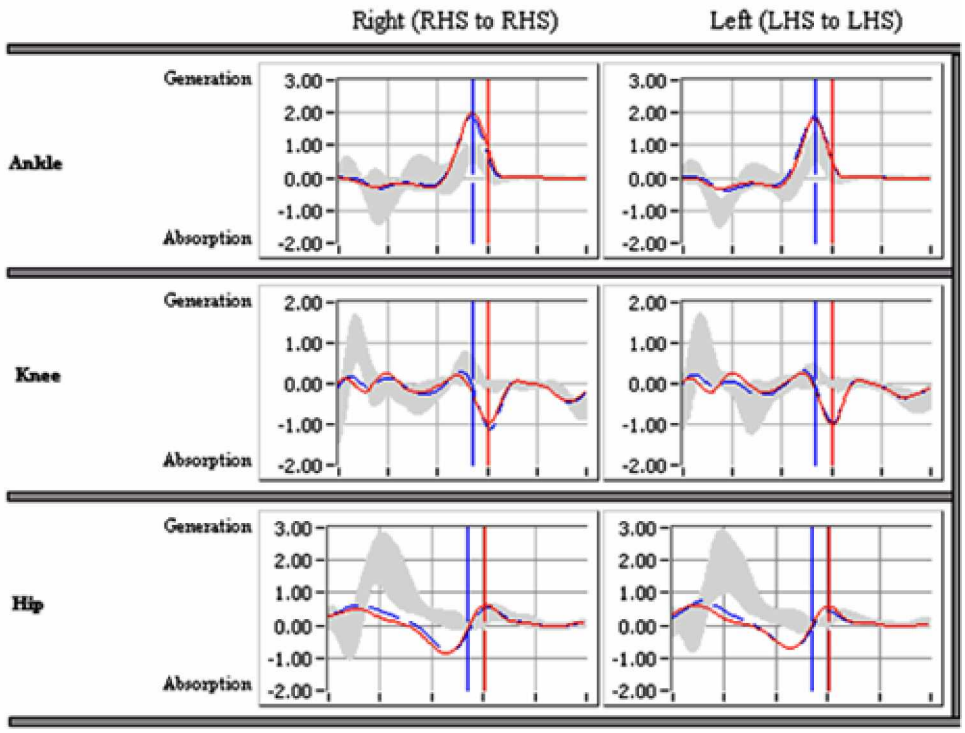

Figure C.8 Sagittal Joint Powers (Watts/Kg), 5-year-old subjects.

Table C.5 Stance Phase Kinetics of 7-year-old Female Subjects.

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	0.20	0.06	1.02	0.06	30.20	17.73	0.17	0.06	53.70	18.91
L_Hip_Rot_Frc	0.20	0.08	1.02	0.06	29.80	17.75	0.14	0.02	29.40	31.01
R_Hip_Abd_Frc	-0.09	0.02	0.25	0.08	47.00	1.15	-0.22	0.11	9.40	2.01
L_Hip_Abd_Frc	-0.09	0.03	0.25	0.09	46.20	1.48	-0.22	0.08	9.80	2.74
R_Hip_Flex_Frc	0.02	0.03	0.18	0.06	29.70	15.99	0.00	0.02	29.00	30.68
L_Hip_Flex_Frc	0.02	0.01	0.18	0.04	32.80	15.16	0.01	0.01	23.60	30.48
R_Knee_Rot_Frc	0.27	0.07	1.09	0.07	29.80	17.73	0.19	0.06	59.70	1.25
L_Knee_Rot_Frc	0.27	0.09	1.10	0.06	26.40	17.56	0.18	0.03	47.30	24.95
R_Knee_Abd_Frc	-0.07	0.01	0.36	0.05	50.00	1.25	-0.08	0.02	1.40	1.65
L_Knee_Abd_Frc	-0.07	0.02	0.34	0.04	50.00	1.25	-0.08	0.03	1.50	1.72
R_Knee_Flex_Frc	-0.01	0.02	0.16	0.07	26.40	16.11	-0.02	0.02	17.80	25.95
L_Knee_Flex_Frc	-0.01	0.01	0.15	0.05	22.80	13.07	-0.01	0.02	6.60	16.78
R_Ank_Rot_Frc	0.30	0.07	1.15	0.07	39.90	14.20	0.23	0.07	59.70	1.25
L_Ank_Rot_Frc	0.30	0.09	1.15	0.06	33.20	16.99	0.21	0.03	41.40	28.59
R_Ank_Abd_Frc	-0.08	0.02	0.23	0.03	54.80	1.23	-0.10	0.03	2.00	1.63
L_Ank_Abd_Frc	-0.07	0.02	0.21	0.04	54.50	1.72	-0.09	0.03	10.10	16.41
R_Ank_Flex_Frc	0.00	0.01	0.06	0.03	26.40	9.47	-0.02	0.02	42.00	25.97
L_Ank_Flex_Frc	0.01	0.01	0.07	0.03	27.50	11.13	-0.02	0.01	45.50	24.33
R_GRF_Fwd_Frc	-0.05	0.06	0.21	0.03	53.30	0.82	-0.20	0.03	9.70	1.06
L_GRF_Fwd_Frc	-0.04	0.04	0.21	0.04	52.70	1.25	-0.21	0.04	8.80	1.93
R_GRF_Lat_Frc	-0.01	0.02	0.06	0.01	28.80	18.13	-0.03	0.02	2.50	1.72
L_GRF_Lat_Frc	0.00	0.02	0.06	0.01	21.70	13.09	-0.02	0.02	18.90	26.79
R_GRF_Vrt_Frc	0.27	0.24	1.20	0.09	37.30	16.57	0.13	0.12	35.50	30.57
L_GRF_Vrt_Frc	0.26	0.29	1.21	0.08	33.70	17.63	0.09	0.10	29.20	30.79
R_Hip_Rot_Mom	0.00	0.03	0.18	0.10	12.60	1.35	-0.18	0.07	47.70	3.97
L_Hip_Rot_Mom	-0.01	0.03	0.14	0.07	16.90	12.15	-0.14	0.08	42.10	13.95
R_Hip_Abd_Mom	0.03	0.08	0.50	0.09	25.90	13.44	-0.03	0.05	23.80	30.73
L_Hip_Abd_Mom	0.02	0.07	0.52	0.05	33.70	15.09	0.01	0.06	17.70	28.51
R_Hip_Flex_Mom	0.46	0.05	0.59	0.11	5.00	1.89	-0.53	0.14	50.80	0.92
L_Hip_Flex_Mom	0.43	0.08	0.57	0.12	5.80	1.93	-0.46	0.12	50.50	1.90
R_Knee_Rot_Mom	0.02	0.03	0.16	0.10	15.60	15.67	-0.17	0.07	47.50	5.25
L_Knee_Rot_Mom	0.00	0.03	0.11	0.08	15.20	12.48	-0.14	0.08	43.90	11.96
R_Knee_Abd_Mom	-0.03	0.04	0.20	0.10	16.80	1.14	-0.08	0.06	32.20	27.71
L_Knee_Abd_Mom	-0.02	0.03	0.20	0.10	19.10	8.12	-0.04	0.03	11.10	20.52
R_Knee_Flex_Mom	-0.16	0.05	0.22	0.14	36.80	23.20	-0.27	0.14	37.60	13.28
L_Knee_Flex_Mom	-0.16	0.06	0.16	0.05	40.70	22.81	-0.33	0.15	37.30	13.39
R_Ank_Rot_Mom	-0.02	0.03	0.18	0.08	46.70	6.78	-0.16	0.10	15.50	15.73
L_Ank_Rot_Mom	0.00	0.03	0.14	0.08	43.60	11.90	-0.11	0.08	14.60	12.88
R_Ank_Abd_Mom	-0.01	0.02	0.03	0.06	35.20	21.76	-0.06	0.04	23.20	18.00
L_Ank_Abd_Mom	-0.01	0.02	0.05	0.04	41.50	18.68	-0.05	0.04	19.10	11.91
R_Ank_Flex_Mom	0.00	0.03	1.11	0.14	46.90	1.10	-0.03	0.03	2.90	1.10
L_Ank_Flex_Mom	0.01	0.03	1.10	0.09	46.80	1.55	-0.01	0.04	2.40	2.27
R_Hip_Pwr	0.20	0.20	0.75	0.22	31.10	24.80	-0.70	0.26	41.00	13.05
L_Hip_Pwr	0.20	0.26	0.80	0.24	16.60	14.96	-0.62	0.20	45.80	2.66
R_Knee_Pwr	0.00	0.17	0.45	0.15	36.70	14.44	-1.11	0.22	58.70	1.06
L_Knee_Pwr	0.05	0.20	0.49	0.26	42.00	11.86	-0.97	0.26	58.70	1.42
R_Ank_Pwr	-0.01	0.04	2.43	0.50	52.00	1.25	-0.52	0.17	30.20	10.81
L_Ank_Pwr	0.01	0.01	2.26	0.58	52.10	1.60	-0.56	0.12	30.30	11.70

Table C.6 Swing Phase Kinetics of 7-year-old Female Subjects.

	Maximum Swing		Time of Max. Sw.		Minimum Swing		Time of Min. Sw.		Toe Off	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	0.10	0.06	60.30	1.26	-0.11	0.01	73.70	13.14	0.10	0.06
L_Hip_Rot_Frc	0.08	0.03	59.80	1.15	-0.11	0.01	73.10	13.46	0.08	0.03
R_Hip_Abd_Frc	0.02	0.01	64.90	4.72	0.00	0.01	89.70	9.71	0.02	0.01
L_Hip_Abd_Frc	0.02	0.01	66.70	7.48	0.00	0.00	88.20	13.86	0.02	0.01
R_Hip_Flex_Frc	0.01	0.01	63.40	7.09	-0.01	0.00	81.90	14.25	0.01	0.01
L_Hip_Flex_Frc	0.01	0.01	63.20	11.09	-0.01	0.00	82.20	14.77	0.01	0.01
R_Knee_Rot_Frc	0.13	0.05	60.30	1.26	-0.05	0.00	70.30	7.87	0.13	0.05
L_Knee_Rot_Frc	0.11	0.02	59.80	1.15	-0.05	0.00	69.60	8.84	0.11	0.02
R_Knee_Abd_Frc	0.10	0.03	60.30	1.26	-0.03	0.00	93.20	2.36	0.10	0.03
L_Knee_Abd_Frc	0.09	0.02	59.80	1.15	-0.03	0.00	93.40	1.62	0.09	0.02
R_Knee_Flex_Frc	0.03	0.03	71.20	17.82	-0.01	0.01	68.10	6.57	0.02	0.03
L_Knee_Flex_Frc	0.03	0.02	66.90	15.48	-0.01	0.00	66.90	2.41	0.03	0.02
R_Ank_Rot_Frc	0.16	0.06	60.30	1.26	-0.03	0.00	68.80	0.63	0.16	0.06
L_Ank_Rot_Frc	0.15	0.03	59.80	1.15	-0.03	0.00	68.10	0.86	0.15	0.03
R_Ank_Abd_Frc	0.10	0.03	60.30	1.26	-0.02	0.00	75.70	12.39	0.10	0.03
L_Ank_Abd_Frc	0.10	0.01	59.80	1.15	-0.02	0.00	73.20	11.61	0.10	0.01
R_Ank_Flex_Frc	0.00	0.00	80.20	10.27	-0.01	0.01	60.40	1.33	-0.01	0.01
L_Ank_Flex_Frc	0.00	0.00	86.10	10.49	-0.01	0.01	60.50	1.60	-0.01	0.01
R_GRF_Fwd_Frc	0.04	0.01	60.30	1.26	0.00	0.00	64.60	1.25	0.04	0.01
L_GRF_Fwd_Frc	0.03	0.02	59.80	1.15	0.00	0.00	64.00	1.72	0.03	0.02
R_GRF_Lat_Frc	0.00	0.00	63.70	1.98	0.00	0.00	61.10	2.18	0.00	0.01
L_GRF_Lat_Frc	0.00	0.00	62.60	2.17	0.00	0.00	60.80	1.69	0.00	0.01
R_GRF_Vrt_Frc	0.12	0.05	60.30	1.26	0.00	0.00	64.90	1.26	0.12	0.05
L_GRF_Vrt_Frc	0.10	0.04	59.80	1.15	0.00	0.00	64.50	1.00	0.10	0.04
R_Hip_Rot_Mom	0.01	0.01	66.50	6.89	-0.03	0.02	63.00	3.98	-0.02	0.04
L_Hip_Rot_Mom	0.01	0.02	64.20	7.19	-0.02	0.02	70.90	13.32	-0.01	0.03
R_Hip_Abd_Mom	0.04	0.03	71.30	18.42	-0.03	0.02	70.50	11.68	0.02	0.06
L_Hip_Abd_Mom	0.04	0.03	65.60	13.01	-0.03	0.01	77.00	15.90	0.04	0.03
R_Hip_Flex_Mom	0.11	0.02	96.40	1.31	-0.23	0.04	60.30	1.26	-0.23	0.04
L_Hip_Flex_Mom	0.08	0.01	97.90	0.82	-0.19	0.04	59.80	1.15	-0.19	0.04
R_Knee_Rot_Mom	0.01	0.00	64.40	2.75	-0.02	0.02	67.20	12.13	-0.02	0.03
L_Knee_Rot_Mom	0.01	0.01	63.40	2.62	-0.02	0.02	67.40	12.83	-0.01	0.02
R_Knee_Abd_Mom	0.04	0.05	77.30	18.48	-0.03	0.03	72.30	14.08	0.01	0.07
L_Knee_Abd_Mom	0.04	0.05	70.20	17.17	-0.02	0.01	71.80	7.27	0.03	0.06
R_Knee_Flex_Mom	0.14	0.04	60.30	1.26	-0.07	0.01	94.60	1.05	0.14	0.04
L_Knee_Flex_Mom	0.12	0.03	59.80	1.15	-0.05	0.00	94.00	3.02	0.12	0.03
R_Ank_Rot_Mom	0.02	0.03	67.10	12.12	-0.01	0.00	64.20	3.28	0.02	0.03
L_Ank_Rot_Mom	0.02	0.02	67.90	13.37	-0.01	0.01	63.30	2.55	0.01	0.02
R_Ank_Abd_Mom	0.01	0.02	66.60	10.15	-0.01	0.02	64.00	3.83	0.00	0.03
L_Ank_Abd_Mom	0.01	0.02	73.10	15.81	-0.01	0.00	63.10	3.48	0.01	0.02
R_Ank_Flex_Mom	0.14	0.05	60.30	1.26	-0.03	0.00	67.50	0.88	0.14	0.05
L_Ank_Flex_Mom	0.14	0.03	59.80	1.15	-0.03	0.00	66.80	0.93	0.14	0.03
R_Hip_Pwr	0.56	0.12	60.50	0.89	-0.04	0.02	84.90	1.88	0.56	0.13
L_Hip_Pwr	0.44	0.15	60.10	1.19	-0.03	0.01	85.60	3.17	0.44	0.15
R_Knee_Pwr	0.07	0.04	70.10	3.03	-1.00	0.19	60.30	1.26	-1.00	0.19
L_Knee_Pwr	0.09	0.05	68.30	1.06	-0.88	0.21	59.80	1.15	-0.88	0.21
R_Ank_Pwr	0.30	0.14	60.30	1.26	0.00	0.00	87.70	8.04	0.30	0.14
L_Ank_Pwr	0.32	0.13	59.80	1.15	0.00	0.00	83.90	10.30	0.32	0.13

Table C.7 Stance Phase Kinetics of 7-year-old Male Subjects.

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	0.14	0.04	1.02	0.06	21.10	13.41	0.12	0.05	24.20	31.24
L_Hip_Rot_Frc	0.16	0.06	1.01	0.05	20.90	13.54	0.13	0.06	30.40	32.06
R_Hip_Abd_Frc	-0.07	0.02	0.26	0.03	47.20	0.79	-0.20	0.07	11.20	0.92
L_Hip_Abd_Frc	-0.07	0.02	0.27	0.03	47.50	1.08	-0.19	0.08	9.90	1.66
R_Hip_Flex_Frc	0.02	0.01	0.15	0.03	24.40	12.44	0.01	0.01	41.50	28.69
L_Hip_Flex_Frc	0.01	0.02	0.16	0.04	33.90	14.12	0.00	0.01	24.20	30.61
R_Knee_Rot_Frc	0.21	0.05	1.08	0.07	17.50	10.38	0.16	0.05	36.30	31.24
L_Knee_Rot_Frc	0.22	0.06	1.08	0.06	20.30	13.61	0.17	0.06	42.40	29.28
R_Knee_Abd_Frc	-0.07	0.01	0.33	0.04	50.20	1.40	-0.08	0.02	1.80	1.48
L_Knee_Abd_Frc	-0.07	0.02	0.30	0.03	51.10	1.66	-0.09	0.03	2.30	1.49
R_Knee_Flex_Frc	0.00	0.02	0.16	0.04	20.10	9.50	-0.01	0.01	29.50	29.29
L_Knee_Flex_Frc	-0.01	0.02	0.16	0.04	20.30	10.18	-0.01	0.02	12.20	23.91
R_Ank_Rot_Frc	0.23	0.05	1.14	0.06	24.20	15.52	0.20	0.06	36.30	31.24
L_Ank_Rot_Frc	0.25	0.06	1.12	0.06	23.90	15.76	0.20	0.06	42.40	29.28
R_Ank_Abd_Frc	-0.07	0.02	0.19	0.03	55.70	1.25	-0.10	0.03	2.60	0.84
L_Ank_Abd_Frc	-0.08	0.02	0.18	0.03	56.20	1.62	-0.10	0.03	2.70	0.82
R_Ank_Flex_Frc	0.00	0.01	0.07	0.03	21.00	4.78	-0.02	0.01	51.90	18.29
L_Ank_Flex_Frc	0.00	0.01	0.09	0.03	26.00	10.80	-0.02	0.01	30.10	29.88
R_GRF_Fwd_Frc	-0.01	0.03	0.19	0.03	54.00	1.33	-0.18	0.03	9.80	1.48
L_GRF_Fwd_Frc	-0.03	0.08	0.19	0.02	54.30	0.95	-0.19	0.04	9.10	3.38
R_GRF_Lat_Frc	0.00	0.01	0.06	0.01	31.20	14.43	-0.03	0.03	8.70	17.72
L_GRF_Lat_Frc	-0.01	0.01	0.07	0.01	22.20	14.05	-0.03	0.02	19.90	27.01
R_GRF_Vrt_Frc	0.08	0.19	1.18	0.07	21.00	13.74	0.05	0.11	0.10	0.32
L_GRF_Vrt_Frc	0.19	0.32	1.16	0.06	21.00	14.02	0.08	0.13	18.00	28.98
R_Hip_Rot_Mom	-0.01	0.02	0.18	0.07	18.10	15.15	-0.18	0.06	49.00	1.94
L_Hip_Rot_Mom	0.00	0.03	0.15	0.06	17.50	14.28	-0.18	0.05	48.30	3.09
R_Hip_Abd_Mom	0.07	0.05	0.58	0.09	18.40	1.43	0.00	0.05	53.70	18.90
L_Hip_Abd_Mom	-0.02	0.05	0.52	0.09	21.30	8.81	-0.02	0.03	12.00	25.30
R_Hip_Flex_Mom	0.42	0.07	0.53	0.11	5.20	1.40	-0.56	0.09	50.40	1.35
L_Hip_Flex_Mom	0.40	0.06	0.53	0.13	5.40	1.43	-0.48	0.08	51.00	1.63
R_Knee_Rot_Mom	0.01	0.02	0.13	0.06	16.40	15.73	-0.18	0.07	49.40	1.90
L_Knee_Rot_Mom	0.01	0.03	0.12	0.05	16.10	15.47	-0.18	0.05	49.10	2.51
R_Knee_Abd_Mom	-0.01	0.05	0.26	0.08	16.80	1.23	-0.05	0.05	39.30	27.22
L_Knee_Abd_Mom	-0.03	0.05	0.22	0.08	20.10	10.25	-0.06	0.06	27.70	28.79
R_Knee_Flex_Mom	-0.17	0.03	0.21	0.09	32.80	22.36	-0.25	0.07	41.80	2.20
L_Knee_Flex_Mom	-0.16	0.06	0.14	0.06	37.30	23.73	-0.37	0.10	42.20	1.75
R_Ank_Rot_Mom	-0.01	0.02	0.18	0.07	49.30	2.31	-0.13	0.06	16.30	15.73
L_Ank_Rot_Mom	-0.01	0.03	0.18	0.04	48.40	3.06	-0.12	0.05	16.00	15.51
R_Ank_Abd_Mom	0.00	0.02	0.05	0.04	46.20	12.32	-0.04	0.04	25.40	20.03
L_Ank_Abd_Mom	-0.01	0.02	0.03	0.04	49.00	17.63	-0.06	0.03	23.10	10.60
R_Ank_Flex_Mom	0.01	0.02	1.06	0.18	47.10	1.20	-0.02	0.05	2.90	1.73
L_Ank_Flex_Mom	0.00	0.03	1.08	0.17	47.40	1.58	-0.04	0.05	3.30	1.42
R_Hip_Pwr	0.16	0.19	0.68	0.23	41.60	23.62	-0.74	0.08	45.40	1.17
L_Hip_Pwr	0.20	0.16	0.73	0.34	11.10	2.47	-0.64	0.12	46.60	1.65
R_Knee_Pwr	0.00	0.09	0.38	0.19	28.70	19.55	-0.94	0.30	59.50	0.97
L_Knee_Pwr	0.04	0.14	0.50	0.21	39.30	17.76	-0.78	0.25	60.30	0.82
R_Ank_Pwr	0.00	0.01	2.19	0.47	53.40	1.07	-0.58	0.15	27.50	12.21
L_Ank_Pwr	0.00	0.02	2.16	0.54	53.80	1.48	-0.56	0.19	26.70	11.71

Table C.8 Swing Phase Kinetics of 7-year-old Male Subjects.

	Maximum Swing		Time of Max. Sw.		Minimum Swing		Time of Min. Sw.		Toe Off	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	0.11	0.08	60.61	1.17	-0.10	0.01	71.21	9.66	0.11	0.08
L_Hip_Rot_Frc	0.08	0.05	61.11	1.19	-0.11	0.01	68.21	0.97	0.08	0.05
R_Hip_Abd_Frc	0.03	0.01	63.51	7.83	0.00	0.00	93.91	9.24	0.03	0.01
L_Hip_Abd_Frc	0.03	0.01	64.71	7.93	-0.01	0.01	93.81	9.10	0.03	0.01
R_Hip_Flex_Frc	0.01	0.01	69.91	13.33	0.00	0.00	78.71	15.67	0.00	0.01
L_Hip_Flex_Frc	0.01	0.01	74.01	15.31	0.00	0.00	73.61	12.95	0.00	0.01
R_Knee_Rot_Frc	0.14	0.08	60.61	1.17	-0.05	0.00	72.81	9.96	0.14	0.08
L_Knee_Rot_Frc	0.11	0.05	61.11	1.19	-0.05	0.00	76.11	12.85	0.11	0.05
R_Knee_Abd_Frc	0.10	0.04	60.61	1.17	-0.03	0.00	94.81	1.93	0.10	0.04
L_Knee_Abd_Frc	0.09	0.02	61.11	1.19	-0.03	0.00	95.11	2.46	0.09	0.02
R_Knee_Flex_Frc	0.01	0.01	75.51	18.61	-0.01	0.00	69.91	5.60	0.01	0.01
L_Knee_Flex_Frc	0.02	0.02	68.21	15.79	-0.01	0.00	68.61	1.34	0.02	0.02
R_Ank_Rot_Frc	0.17	0.08	60.61	1.17	-0.03	0.00	69.31	1.16	0.17	0.08
L_Ank_Rot_Frc	0.15	0.05	61.11	1.19	-0.03	0.00	69.31	1.34	0.15	0.05
R_Ank_Abd_Frc	0.10	0.04	60.61	1.17	-0.02	0.00	90.11	12.16	0.10	0.04
L_Ank_Abd_Frc	0.09	0.02	61.11	1.19	-0.02	0.00	87.31	13.22	0.09	0.02
R_Ank_Flex_Frc	0.00	0.00	82.11	11.46	-0.02	0.01	61.11	1.59	-0.01	0.01
L_Ank_Flex_Frc	0.00	0.00	85.41	12.25	-0.01	0.01	62.31	2.72	-0.01	0.01
R_GRF_Fwd_Frc	0.05	0.03	60.61	1.17	0.00	0.00	65.01	0.84	0.05	0.03
L_GRF_Fwd_Frc	0.04	0.03	61.11	1.19	0.00	0.00	65.51	1.20	0.04	0.03
R_GRF_Lat_Frc	0.00	0.00	63.31	2.27	0.00	0.00	61.71	1.53	0.00	0.01
L_GRF_Lat_Frc	0.00	0.00	64.61	2.06	-0.01	0.00	61.91	1.17	0.00	0.00
R_GRF_Vrt_Frc	0.15	0.09	60.61	1.17	0.00	0.00	65.31	0.95	0.15	0.09
L_GRF_Vrt_Frc	0.12	0.06	61.11	1.19	0.00	0.00	65.61	1.25	0.12	0.06
R_Hip_Rot_Mom	0.01	0.01	75.91	6.64	-0.04	0.04	67.21	14.48	-0.03	0.05
L_Hip_Rot_Mom	0.00	0.01	77.61	9.24	-0.02	0.01	63.31	3.43	-0.02	0.02
R_Hip_Abd_Mom	0.03	0.01	87.31	18.19	-0.03	0.03	67.31	8.07	0.00	0.04
L_Hip_Abd_Mom	0.03	0.02	73.71	14.34	-0.02	0.01	71.51	12.23	0.02	0.03
R_Hip_Flex_Mom	0.13	0.02	97.81	1.03	-0.25	0.06	60.61	1.17	-0.25	0.06
L_Hip_Flex_Mom	0.10	0.02	98.21	0.52	-0.19	0.03	61.11	1.19	-0.19	0.03
R_Knee_Rot_Mom	0.01	0.01	65.51	1.91	-0.03	0.04	63.31	6.66	-0.03	0.04
L_Knee_Rot_Mom	0.01	0.00	65.21	2.12	-0.02	0.02	64.11	9.38	-0.02	0.02
R_Knee_Abd_Mom	0.02	0.01	81.01	16.36	-0.03	0.03	71.01	13.20	-0.01	0.04
L_Knee_Abd_Mom	0.03	0.03	78.71	18.69	-0.02	0.01	69.51	6.71	0.02	0.04
R_Knee_Flex_Mom	0.13	0.03	60.71	1.01	-0.08	0.01	96.41	1.32	0.13	0.03
L_Knee_Flex_Mom	0.10	0.01	61.11	1.19	-0.05	0.01	95.61	3.84	0.10	0.01
R_Ank_Rot_Mom	0.03	0.04	63.31	6.66	-0.01	0.01	65.51	2.02	0.03	0.04
L_Ank_Rot_Mom	0.02	0.02	65.81	10.51	-0.01	0.00	65.11	2.18	0.02	0.02
R_Ank_Abd_Mom	0.01	0.01	77.41	15.64	-0.01	0.01	63.61	3.81	0.00	0.02
L_Ank_Abd_Mom	0.01	0.01	70.71	13.25	-0.01	0.00	64.91	4.38	0.00	0.02
R_Ank_Flex_Mom	0.16	0.09	60.61	1.17	-0.02	0.00	68.21	1.08	0.16	0.09
L_Ank_Flex_Mom	0.14	0.05	61.11	1.19	-0.02	0.00	68.31	1.34	0.14	0.05
R_Hip_Pwr	0.58	0.14	60.81	0.80	-0.02	0.02	87.41	4.18	0.58	0.14
L_Hip_Pwr	0.42	0.10	61.31	1.17	-0.03	0.02	88.31	3.03	0.42	0.10
R_Knee_Pwr	0.06	0.03	70.81	2.70	-0.90	0.27	60.71	1.01	-0.90	0.27
L_Knee_Pwr	0.08	0.05	70.41	1.32	-0.78	0.23	61.31	1.17	-0.78	0.23
R_Ank_Pwr	0.45	0.31	60.61	1.17	0.00	0.00	89.41	3.76	0.45	0.31
L_Ank_Pwr	0.35	0.21	61.11	1.19	0.00	0.00	88.41	1.93	0.35	0.21

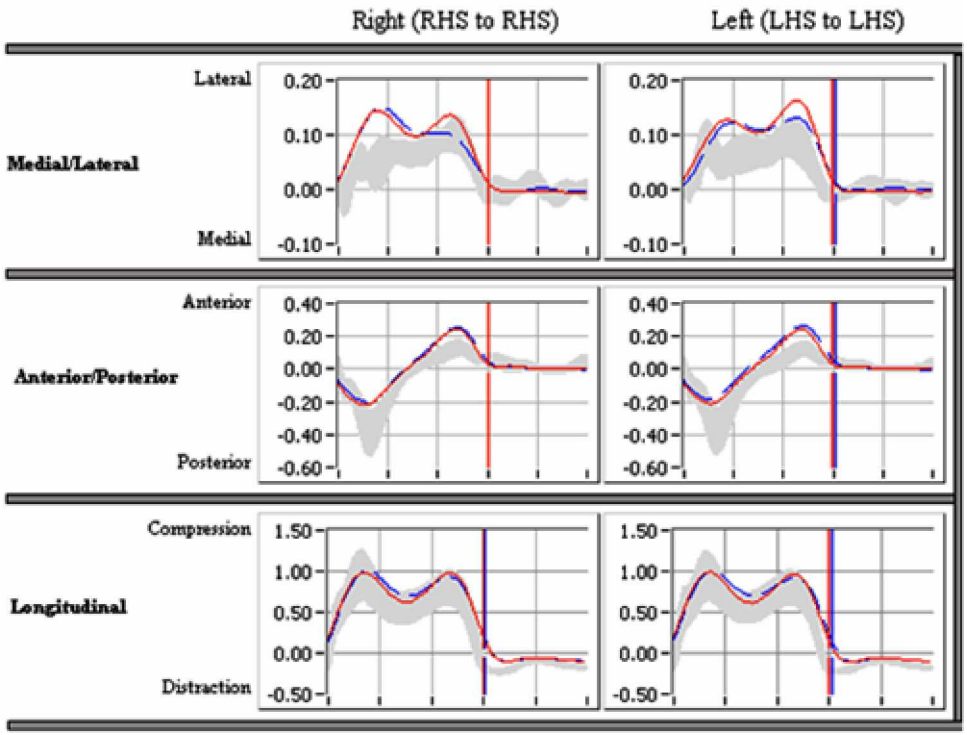

Figure C.9 Hip Joint Forces (N), 7-year-old subjects.

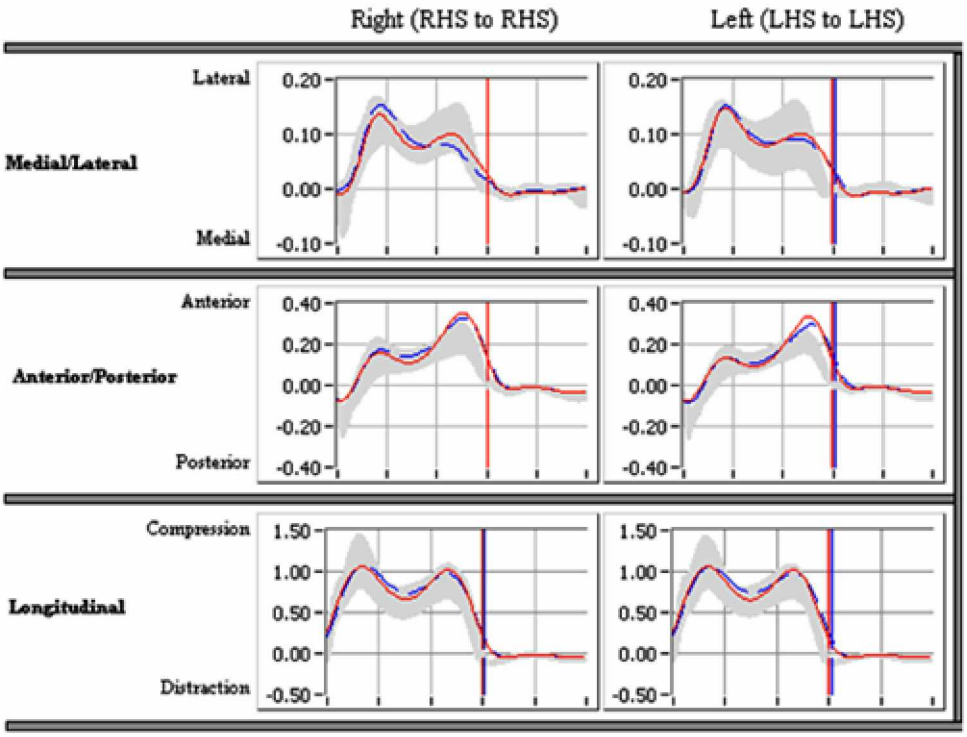

Figure C.10 Knee Joint Forces (N), 7-year-old subjects.

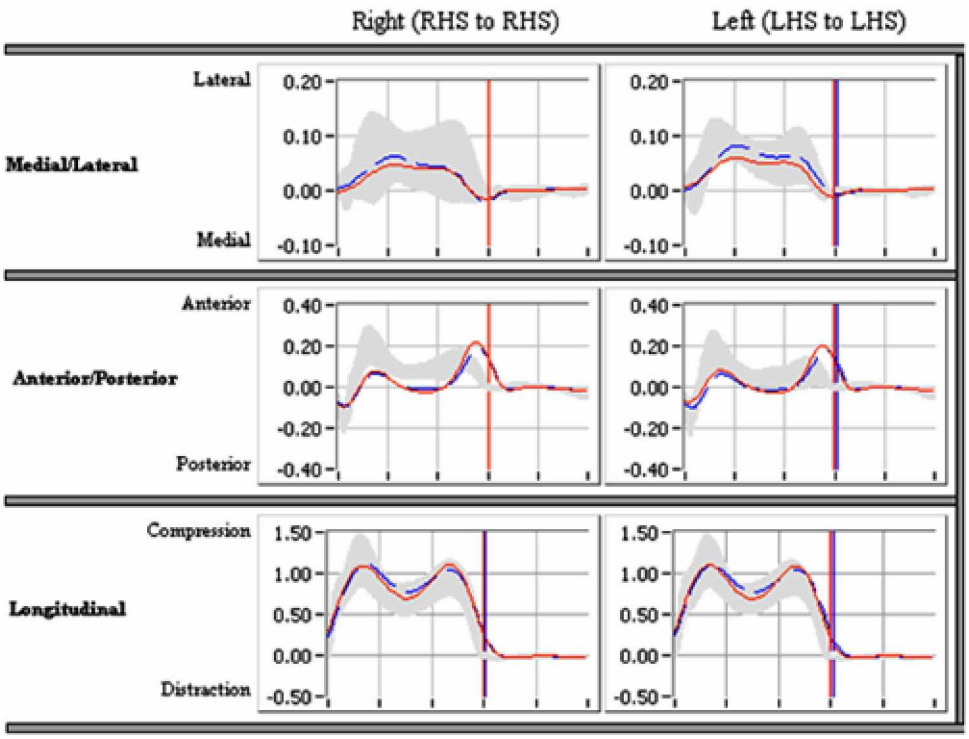

Figure C.11 Ankle Joint Forces (N), 7-year-old subjects.

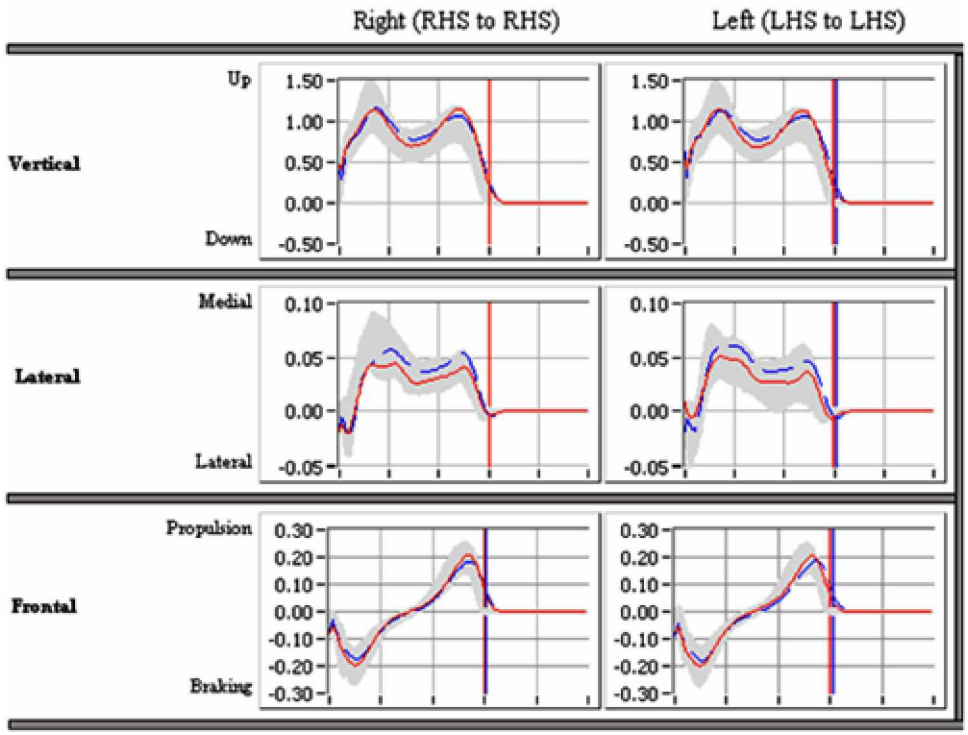

Figure C.12 Ground Reaction Forces (N), 7-year-old subjects.

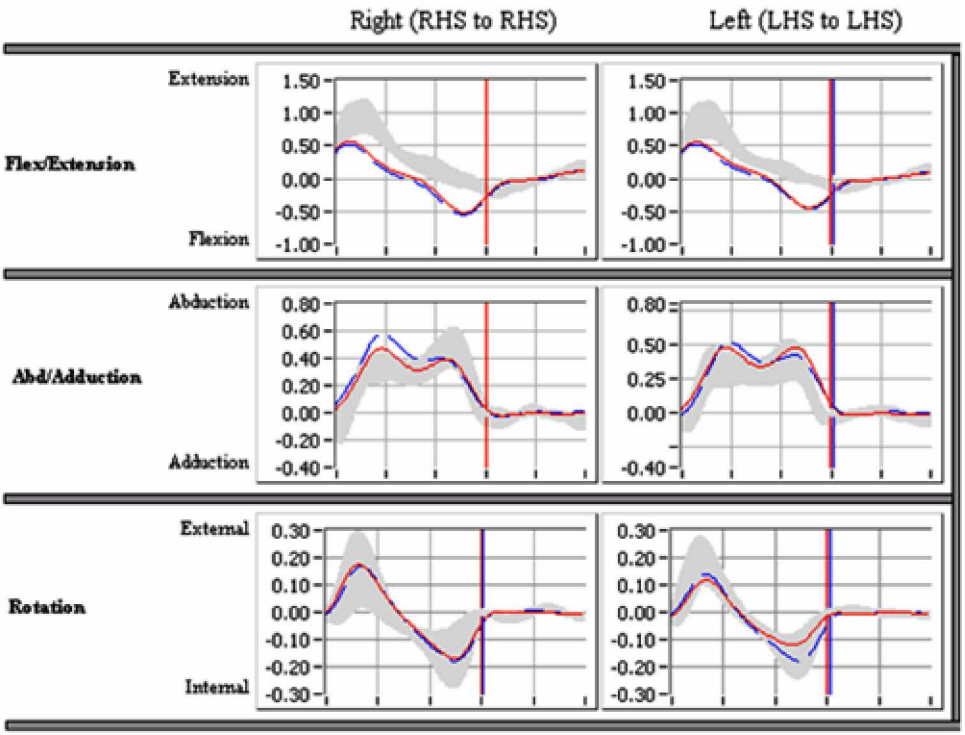

Figure C.13 Hip Joint Moments (Nm/Kg), 7-year-old subjects.

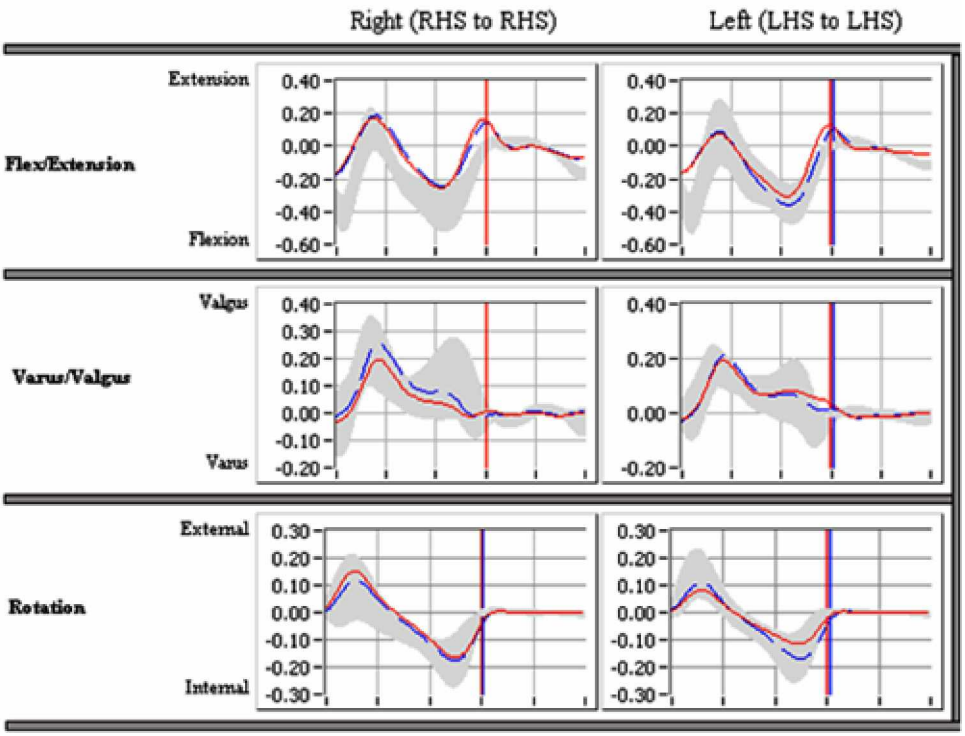

Figure C.14 Knee Joint Moments (Nm/Kg), 7-year-old subjects.

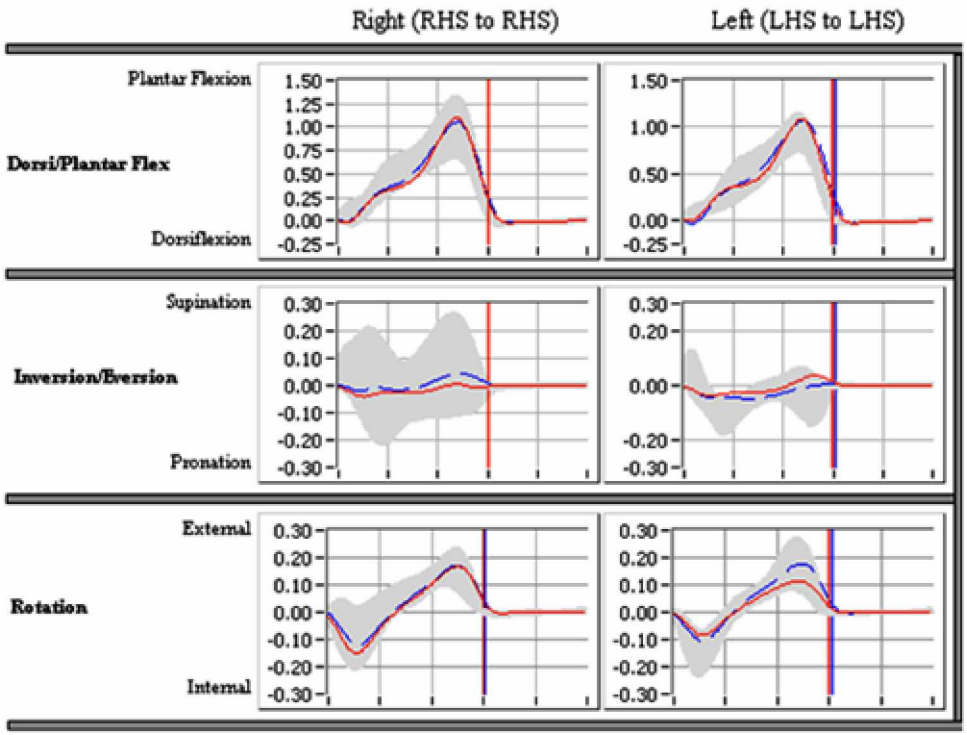

Figure C.15 Ankle Joint Moments (Nm/Kg), 7-year-old subjects.

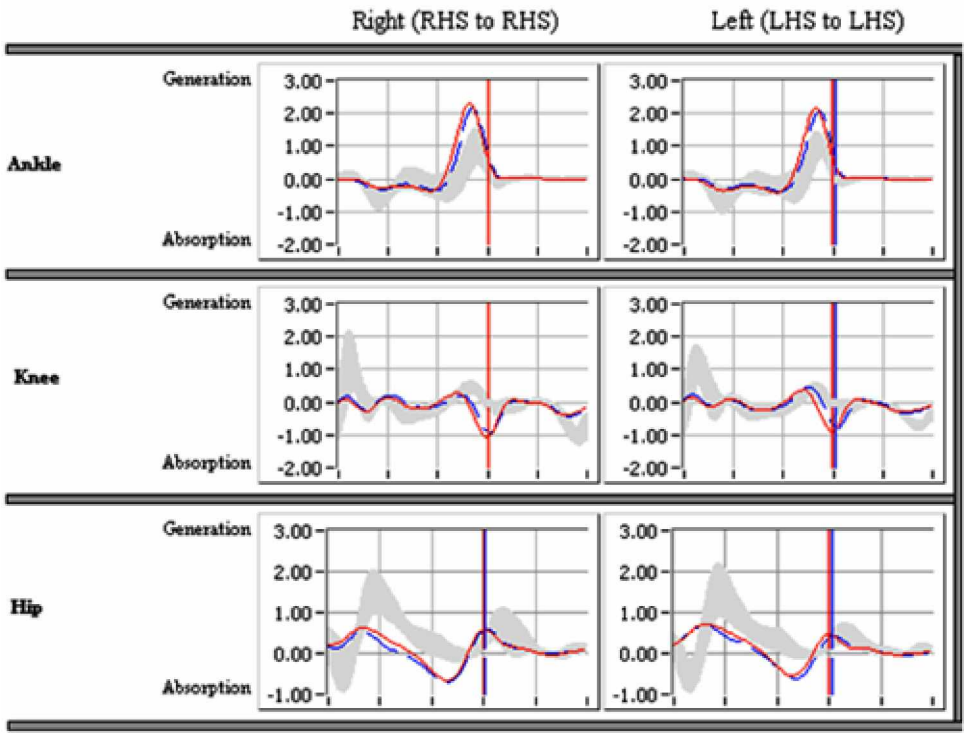

Figure C.16 Sagittal Joint Powers (Watts/Kg), 7-year-old subjects.

Table C.9 Stance Phase Kinetics of 8-year-old Female Subjects.

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	0.10	0.03	1.06	0.07	27.40	16.04	0.09	0.05	18.30	29.47
L_Hip_Rot_Frc	0.10	0.04	1.04	0.08	24.30	15.48	0.09	0.05	23.90	30.86
R_Hip_Abd_Frc	-0.05	0.02	0.23	0.05	47.40	1.07	-0.22	0.09	11.40	1.71
L_Hip_Abd_Frc	-0.05	0.02	0.25	0.04	47.60	1.26	-0.20	0.09	11.00	1.41
R_Hip_Flex_Frc	0.01	0.01	0.17	0.04	34.00	14.64	0.00	0.01	24.80	30.99
L_Hip_Flex_Frc	0.01	0.01	0.16	0.03	31.80	14.69	0.00	0.01	23.50	30.05
R_Knee_Rot_Frc	0.17	0.04	1.11	0.07	23.70	15.18	0.13	0.04	42.30	29.20
L_Knee_Rot_Frc	0.17	0.04	1.08	0.07	23.90	15.74	0.14	0.04	35.80	30.82
R_Knee_Abd_Frc	-0.05	0.02	0.35	0.04	49.80	1.40	-0.06	0.02	1.80	1.03
L_Knee_Abd_Frc	-0.06	0.01	0.34	0.05	50.40	1.78	-0.07	0.02	1.90	1.20
R_Knee_Flex_Frc	-0.01	0.01	0.20	0.10	22.90	12.49	-0.01	0.01	1.60	1.43
L_Knee_Flex_Frc	0.00	0.01	0.20	0.11	20.00	9.65	-0.01	0.01	12.90	24.36
R_Ank_Rot_Frc	0.20	0.04	1.17	0.08	27.20	16.21	0.16	0.05	36.30	31.25
L_Ank_Rot_Frc	0.20	0.04	1.15	0.09	24.10	15.85	0.17	0.05	29.90	31.53
R_Ank_Abd_Frc	-0.05	0.02	0.21	0.04	50.90	12.65	-0.06	0.03	6.10	12.31
L_Ank_Abd_Frc	-0.05	0.02	0.21	0.04	55.20	1.75	-0.06	0.03	6.00	12.71
R_Ank_Flex_Frc	0.00	0.01	0.06	0.03	29.20	10.76	-0.03	0.02	43.80	22.85
L_Ank_Flex_Frc	0.01	0.01	0.07	0.03	23.80	13.23	-0.02	0.01	54.10	14.19
R_GRF_Fwd_Frc	-0.01	0.04	0.21	0.03	53.60	0.52	-0.21	0.06	9.70	0.82
L_GRF_Fwd_Frc	0.00	0.00	0.21	0.05	53.20	1.69	-0.20	0.04	9.90	0.74
R_GRF_Lat_Frc	0.00	0.00	0.07	0.02	34.50	15.56	-0.02	0.01	3.00	1.25
L_GRF_Lat_Frc	0.00	0.00	0.06	0.02	19.80	11.00	-0.02	0.02	14.20	23.36
R_GRF_Vrt_Frc	0.03	0.09	1.22	0.09	27.30	16.98	0.02	0.06	0.10	0.32
L_GRF_Vrt_Frc	0.00	0.00	1.19	0.11	24.20	16.23	0.00	0.00	0.00	0.00
R_Hip_Rot_Mom	-0.03	0.01	0.11	0.05	26.80	19.56	-0.12	0.06	39.50	13.42
L_Hip_Rot_Mom	-0.02	0.01	0.11	0.07	26.40	19.72	-0.13	0.04	38.30	16.74
R_Hip_Abd_Mom	0.01	0.06	0.60	0.10	26.00	14.11	-0.01	0.06	24.70	31.06
L_Hip_Abd_Mom	0.01	0.08	0.58	0.09	23.00	12.85	-0.02	0.04	24.00	31.00
R_Hip_Flex_Mom	0.35	0.09	0.50	0.16	6.50	0.85	-0.47	0.13	51.10	1.29
L_Hip_Flex_Mom	0.34	0.07	0.47	0.12	6.10	1.45	-0.52	0.20	50.80	1.69
R_Knee_Rot_Mom	-0.01	0.01	0.06	0.05	39.10	23.39	-0.12	0.05	31.20	19.25
L_Knee_Rot_Mom	-0.02	0.02	0.07	0.06	30.20	22.62	-0.14	0.06	39.90	16.52
R_Knee_Abd_Mom	-0.02	0.03	0.28	0.14	15.70	0.95	-0.04	0.04	20.10	26.26
L_Knee_Abd_Mom	-0.01	0.03	0.32	0.16	16.30	2.26	-0.02	0.04	21.50	28.36
R_Knee_Flex_Mom	-0.15	0.04	0.20	0.09	32.30	22.78	-0.28	0.05	42.40	1.90
L_Knee_Flex_Mom	-0.15	0.04	0.19	0.13	36.80	23.86	-0.27	0.11	38.00	13.46
R_Ank_Rot_Mom	0.01	0.01	0.12	0.06	30.50	19.03	-0.07	0.05	38.90	22.63
L_Ank_Rot_Mom	0.02	0.02	0.13	0.07	39.20	16.29	-0.07	0.06	30.00	21.91
R_Ank_Abd_Mom	0.01	0.01	0.11	0.06	48.30	11.62	-0.02	0.03	20.50	14.45
L_Ank_Abd_Mom	0.01	0.01	0.10	0.07	38.00	22.82	-0.02	0.03	19.40	14.18
R_Ank_Flex_Mom	0.01	0.01	1.20	0.16	47.20	1.48	0.00	0.02	2.80	0.92
L_Ank_Flex_Mom	0.00	0.01	1.02	0.37	42.80	15.13	-0.02	0.02	2.80	1.32
R_Hip_Pwr	0.09	0.21	0.64	0.33	20.30	21.22	-0.63	0.34	42.50	15.00
L_Hip_Pwr	0.09	0.18	0.64	0.34	30.10	24.78	-0.65	0.36	41.60	14.82
R_Knee_Pwr	0.04	0.19	0.35	0.26	31.70	18.32	-0.73	0.39	53.80	18.92
L_Knee_Pwr	0.07	0.17	0.42	0.26	33.70	21.18	-0.77	0.44	48.60	23.86
R_Ank_Pwr	0.01	0.01	2.15	0.94	48.00	16.92	-0.65	0.32	23.60	13.83
L_Ank_Pwr	0.00	0.01	2.17	0.89	48.20	17.03	-0.65	0.39	26.70	15.37

Table C.10 Swing Phase Kinetics of 8-year-old Female Subjects.

	Maximum Swing		Time of Max. Sw.		Minimum Swing		Time of Min. Sw.		Toe Off	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	0.04	0.04	61.21	0.98	-0.11	0.01	70.21	10.00	0.04	0.04
L_Hip_Rot_Frc	0.07	0.05	60.81	1.33	-0.11	0.01	70.41	9.98	0.07	0.05
R_Hip_Abd_Frc	0.02	0.01	69.01	8.65	0.00	0.00	86.21	13.50	0.01	0.01
L_Hip_Abd_Frc	0.02	0.01	73.01	11.66	0.00	0.00	88.31	13.19	0.01	0.01
R_Hip_Flex_Frc	0.01	0.01	66.11	8.80	0.00	0.00	86.71	12.60	0.00	0.01
L_Hip_Flex_Frc	0.01	0.01	63.51	5.42	0.00	0.00	79.91	13.56	0.01	0.01
R_Knee_Rot_Frc	0.08	0.03	61.21	0.98	-0.05	0.00	72.71	11.84	0.08	0.03
L_Knee_Rot_Frc	0.10	0.04	60.81	1.33	-0.05	0.00	67.11	1.36	0.10	0.04
R_Knee_Abd_Frc	0.06	0.02	61.21	0.98	-0.03	0.00	95.11	1.72	0.06	0.02
L_Knee_Abd_Frc	0.07	0.03	60.81	1.33	-0.03	0.00	94.51	2.23	0.07	0.03
R_Knee_Flex_Frc	0.01	0.02	72.01	17.69	-0.01	0.01	68.81	4.56	0.01	0.02
L_Knee_Flex_Frc	0.02	0.01	67.61	14.29	-0.01	0.01	69.21	5.49	0.02	0.01
R_Ank_Rot_Frc	0.11	0.03	61.21	0.98	-0.03	0.00	68.51	1.11	0.11	0.03
L_Ank_Rot_Frc	0.13	0.04	60.81	1.33	-0.03	0.00	68.31	1.51	0.13	0.04
R_Ank_Abd_Frc	0.07	0.02	61.21	0.98	-0.02	0.00	73.41	12.52	0.07	0.02
L_Ank_Abd_Frc	0.09	0.03	60.81	1.33	-0.02	0.00	78.71	14.60	0.09	0.03
R_Ank_Flex_Frc	0.00	0.00	87.71	11.19	-0.01	0.01	61.21	0.98	-0.01	0.01
L_Ank_Flex_Frc	0.00	0.00	89.31	8.67	-0.01	0.01	61.21	0.98	-0.01	0.01
R_GRF_Fwd_Frc	0.03	0.02	61.21	0.98	0.00	0.00	65.01	1.72	0.03	0.02
L_GRF_Fwd_Frc	0.04	0.02	60.81	1.33	0.00	0.00	65.01	1.44	0.04	0.02
R_GRF_Lat_Frc	0.00	0.00	63.31	1.83	0.00	0.00	62.41	1.55	0.00	0.00
L_GRF_Lat_Frc	0.00	0.00	64.81	1.49	-0.01	0.00	61.61	2.06	-0.01	0.01
R_GRF_Vrt_Frc	0.09	0.03	61.21	0.98	0.00	0.00	65.01	1.72	0.09	0.03
L_GRF_Vrt_Frc	0.11	0.04	60.91	1.43	0.00	0.00	65.01	1.44	0.11	0.04
R_Hip_Rot_Mom	0.01	0.01	64.51	7.02	-0.01	0.01	84.21	14.53	0.01	0.02
L_Hip_Rot_Mom	0.01	0.02	65.61	8.85	-0.01	0.01	70.31	10.84	0.01	0.03
R_Hip_Abd_Mom	0.03	0.02	73.81	18.01	-0.03	0.01	75.61	14.10	0.02	0.04
L_Hip_Abd_Mom	0.03	0.03	74.61	15.42	-0.02	0.01	81.31	16.66	0.02	0.04
R_Hip_Flex_Mom	0.10	0.01	97.81	1.23	-0.17	0.05	61.21	0.98	-0.17	0.05
L_Hip_Flex_Mom	0.08	0.02	97.81	1.32	-0.17	0.05	60.81	1.33	-0.17	0.05
R_Knee_Rot_Mom	0.01	0.01	62.61	2.67	-0.01	0.01	74.71	12.38	0.01	0.01
L_Knee_Rot_Mom	0.01	0.01	62.71	2.65	-0.01	0.01	77.61	15.61	0.00	0.02
R_Knee_Abd_Mom	0.03	0.02	68.21	12.46	-0.02	0.01	72.61	10.86	0.02	0.03
L_Knee_Abd_Mom	0.04	0.03	72.31	16.64	-0.02	0.01	70.21	6.92	0.04	0.04
R_Knee_Flex_Mom	0.10	0.03	61.21	0.98	-0.07	0.01	96.51	1.46	0.10	0.03
L_Knee_Flex_Mom	0.10	0.03	60.81	1.33	-0.05	0.01	94.31	3.41	0.10	0.03
R_Ank_Rot_Mom	0.01	0.01	71.91	10.84	-0.01	0.01	62.51	2.69	-0.01	0.01
L_Ank_Rot_Mom	0.01	0.01	77.91	16.13	-0.01	0.01	62.81	2.67	0.00	0.02
R_Ank_Abd_Mom	0.02	0.01	64.71	10.90	0.00	0.00	66.61	2.79	0.02	0.01
L_Ank_Abd_Mom	0.03	0.02	63.71	9.88	0.00	0.01	65.71	2.38	0.02	0.03
R_Ank_Flex_Mom	0.10	0.04	61.21	0.98	-0.02	0.01	67.21	1.36	0.10	0.04
L_Ank_Flex_Mom	0.12	0.06	60.81	1.33	-0.02	0.01	66.81	2.49	0.12	0.06
R_Hip_Pwr	0.36	0.20	61.31	0.96	-0.02	0.02	82.61	9.59	0.36	0.20
L_Hip_Pwr	0.40	0.25	61.01	1.28	-0.03	0.04	82.11	10.55	0.39	0.26
R_Knee_Pwr	0.09	0.05	68.51	3.15	-0.64	0.35	61.21	0.98	-0.64	0.35
L_Knee_Pwr	0.10	0.05	67.91	2.87	-0.63	0.34	60.81	1.33	-0.63	0.34
R_Ank_Pwr	0.29	0.17	61.21	0.98	0.00	0.00	83.41	10.61	0.29	0.17
L_Ank_Pwr	0.34	0.19	60.81	1.33	0.00	0.00	84.41	11.54	0.34	0.19

Table C.11 Stance Phase Kinetics of 8-year-old Male Subjects.

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	0.12	0.03	1.07	0.06	23.90	15.54	0.10	0.03	30.10	31.73
L_Hip_Rot_Frc	0.11	0.03	1.07	0.06	20.70	13.63	0.09	0.02	18.40	29.63
R_Hip_Abd_Frc	-0.06	0.02	0.27	0.08	46.90	0.99	-0.20	0.06	11.50	1.96
L_Hip_Abd_Frc	-0.06	0.01	0.26	0.08	47.40	0.97	-0.20	0.07	11.40	1.17
R_Hip_Flex_Frc	0.00	0.01	0.15	0.03	34.90	14.00	0.00	0.01	23.60	29.71
L_Hip_Flex_Frc	0.00	0.01	0.15	0.03	33.00	15.35	0.00	0.01	30.50	30.91
R_Knee_Rot_Frc	0.18	0.03	1.13	0.07	23.30	15.47	0.14	0.04	42.30	29.19
L_Knee_Rot_Frc	0.17	0.03	1.12	0.06	20.50	13.72	0.15	0.03	36.40	31.34
R_Knee_Abd_Frc	-0.07	0.02	0.34	0.05	50.30	1.16	-0.08	0.02	2.40	1.26
L_Knee_Abd_Frc	-0.07	0.01	0.36	0.04	50.50	0.71	-0.08	0.02	1.60	1.26
R_Knee_Flex_Frc	-0.01	0.01	0.19	0.04	25.40	14.77	-0.01	0.01	6.90	17.31
L_Knee_Flex_Frc	0.00	0.02	0.17	0.04	19.30	9.83	-0.01	0.01	12.50	24.79
R_Ank_Rot_Frc	0.21	0.03	1.19	0.07	23.50	15.81	0.17	0.04	42.30	29.19
L_Ank_Rot_Frc	0.20	0.03	1.17	0.07	20.60	13.93	0.18	0.03	18.40	29.63
R_Ank_Abd_Frc	-0.08	0.02	0.19	0.03	55.70	0.95	-0.10	0.03	2.90	0.99
L_Ank_Abd_Frc	-0.07	0.02	0.18	0.02	56.20	0.42	-0.09	0.02	2.60	0.70
R_Ank_Flex_Frc	0.00	0.01	0.08	0.02	34.60	14.86	-0.01	0.01	54.10	17.63
L_Ank_Flex_Frc	0.01	0.01	0.09	0.02	29.80	13.69	-0.01	0.01	48.20	23.40
R_GRF_Fwd_Frc	0.00	0.00	0.20	0.02	53.80	0.92	-0.20	0.03	10.00	1.49
L_GRF_Fwd_Frc	0.00	0.00	0.21	0.03	54.20	0.79	-0.21	0.03	10.00	0.94
R_GRF_Lat_Frc	0.00	0.00	0.07	0.01	33.20	15.83	-0.03	0.01	9.10	17.55
L_GRF_Lat_Frc	0.00	0.00	0.06	0.01	22.50	13.56	-0.02	0.01	25.80	28.81
R_GRF_Vrt_Frc	0.00	0.00	1.24	0.08	23.60	15.95	0.00	0.00	0.00	0.00
L_GRF_Vrt_Frc	0.00	0.00	1.24	0.08	20.60	14.20	0.00	0.00	0.00	0.00
R_Hip_Rot_Mom	-0.01	0.01	0.13	0.07	26.00	20.50	-0.18	0.08	41.90	12.40
L_Hip_Rot_Mom	0.00	0.02	0.14	0.06	17.70	13.54	-0.16	0.08	46.60	3.10
R_Hip_Abd_Mom	-0.01	0.06	0.57	0.12	26.20	14.24	-0.02	0.05	18.10	29.15
L_Hip_Abd_Mom	0.00	0.07	0.57	0.13	28.90	14.67	-0.02	0.06	18.10	28.47
R_Hip_Flex_Mom	0.41	0.08	0.58	0.12	6.20	2.49	-0.52	0.19	50.40	2.07
L_Hip_Flex_Mom	0.36	0.06	0.51	0.12	5.80	2.04	-0.53	0.17	50.10	1.37
R_Knee_Rot_Mom	0.00	0.01	0.08	0.07	25.80	22.28	-0.19	0.06	43.40	11.17
L_Knee_Rot_Mom	0.00	0.01	0.09	0.08	17.30	15.09	-0.17	0.07	47.70	2.31
R_Knee_Abd_Mom	-0.02	0.03	0.29	0.08	16.00	1.25	-0.03	0.03	9.50	20.13
L_Knee_Abd_Mom	-0.01	0.05	0.29	0.08	15.70	1.16	-0.02	0.04	11.60	24.46
R_Knee_Flex_Mom	-0.19	0.04	0.14	0.05	37.80	23.20	-0.35	0.11	42.40	1.58
L_Knee_Flex_Mom	-0.16	0.04	0.19	0.10	33.10	22.96	-0.29	0.13	34.40	17.63
R_Ank_Rot_Mom	0.00	0.01	0.19	0.06	42.80	11.46	-0.09	0.07	24.20	21.99
L_Ank_Rot_Mom	0.00	0.01	0.17	0.08	46.90	2.69	-0.09	0.08	21.20	19.71
R_Ank_Abd_Mom	0.00	0.01	0.09	0.04	42.20	18.62	-0.02	0.03	20.20	14.09
L_Ank_Abd_Mom	0.00	0.01	0.08	0.06	44.70	19.94	-0.04	0.02	26.90	9.43
R_Ank_Flex_Mom	0.02	0.02	1.17	0.15	47.20	0.92	0.00	0.03	2.30	1.83
L_Ank_Flex_Mom	0.01	0.02	1.14	0.15	47.80	0.42	-0.02	0.04	3.10	1.37
R_Hip_Pwr	0.23	0.09	0.73	0.18	27.00	22.11	-0.68	0.24	45.80	2.15
L_Hip_Pwr	0.17	0.09	0.68	0.24	26.60	22.46	-0.69	0.24	45.80	1.87
R_Knee_Pwr	0.08	0.15	0.55	0.26	31.10	23.77	-0.91	0.29	56.10	10.28
L_Knee_Pwr	0.08	0.14	0.48	0.18	31.40	19.82	-0.91	0.25	54.80	15.43
R_Ank_Pwr	0.01	0.02	2.41	0.53	53.40	1.07	-0.64	0.23	28.40	12.28
L_Ank_Pwr	0.01	0.02	2.31	0.35	53.60	0.70	-0.58	0.12	34.50	9.80

Table C.12 Swing Phase Kinetics of 8-year-old Male Subjects.

	Maximum Swing		Time of Max. Sw.		Minimum Swing		Time of Min. Sw.		Toe Off	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	0.08	0.07	60.61	0.95	-0.11	0.01	70.01	8.68	0.08	0.07
L_Hip_Rot_Frc	0.07	0.04	61.01	0.98	-0.11	0.00	70.51	9.91	0.07	0.04
R_Hip_Abd_Frc	0.02	0.01	63.51	3.93	0.00	0.01	86.21	15.32	0.01	0.02
L_Hip_Abd_Frc	0.02	0.01	66.61	7.23	0.00	0.01	85.51	13.55	0.01	0.01
R_Hip_Flex_Frc	0.01	0.00	71.01	13.11	0.00	0.00	79.51	17.91	0.00	0.01
L_Hip_Flex_Frc	0.01	0.01	74.61	10.19	-0.01	0.00	76.01	16.15	0.00	0.01
R_Knee_Rot_Frc	0.11	0.06	60.61	0.95	-0.05	0.00	77.81	13.21	0.11	0.06
L_Knee_Rot_Frc	0.10	0.03	61.01	0.98	-0.05	0.00	78.51	14.55	0.10	0.03
R_Knee_Abd_Frc	0.08	0.03	60.61	0.95	-0.03	0.00	90.91	8.33	0.08	0.03
L_Knee_Abd_Frc	0.08	0.02	61.01	0.98	-0.03	0.00	90.91	8.37	0.08	0.02
R_Knee_Flex_Frc	0.03	0.01	64.31	11.74	-0.02	0.00	67.81	1.14	0.03	0.02
L_Knee_Flex_Frc	0.02	0.01	68.01	14.30	-0.02	0.01	67.81	0.93	0.02	0.02
R_Ank_Rot_Frc	0.14	0.07	60.61	0.95	-0.03	0.00	68.41	1.04	0.14	0.07
L_Ank_Rot_Frc	0.14	0.04	61.01	0.98	-0.03	0.00	68.81	0.80	0.14	0.04
R_Ank_Abd_Frc	0.09	0.03	60.61	0.95	-0.02	0.00	76.01	13.54	0.09	0.03
L_Ank_Abd_Frc	0.08	0.02	61.01	0.98	-0.01	0.00	78.81	14.26	0.08	0.02
R_Ank_Flex_Frc	0.00	0.00	79.81	12.58	-0.01	0.00	61.41	1.55	-0.01	0.01
L_Ank_Flex_Frc	0.00	0.00	82.91	13.56	-0.01	0.01	61.91	1.57	-0.01	0.01
R_GRF_Fwd_Frc	0.04	0.03	60.61	0.95	0.00	0.00	64.21	1.35	0.04	0.03
L_GRF_Fwd_Frc	0.04	0.02	61.01	0.98	0.00	0.00	64.71	1.11	0.04	0.02
R_GRF_Lat_Frc	0.00	0.00	63.41	2.04	-0.01	0.01	61.71	1.80	0.00	0.01
L_GRF_Lat_Frc	0.00	0.00	64.31	1.34	-0.01	0.01	61.61	1.77	-0.01	0.01
R_GRF_Vrt_Frc	0.11	0.07	60.61	0.95	0.00	0.00	64.41	1.23	0.11	0.07
L_GRF_Vrt_Frc	0.11	0.03	61.01	0.98	0.00	0.00	64.91	1.07	0.11	0.03
R_Hip_Rot_Mom	0.02	0.02	66.91	8.50	-0.01	0.01	64.61	4.05	0.01	0.03
L_Hip_Rot_Mom	0.01	0.02	77.11	9.75	-0.02	0.01	63.41	4.27	-0.01	0.03
R_Hip_Abd_Mom	0.05	0.04	67.71	15.02	-0.03	0.01	76.01	14.35	0.04	0.05
L_Hip_Abd_Mom	0.03	0.02	73.41	12.91	-0.03	0.01	76.81	15.43	0.02	0.03
R_Hip_Flex_Mom	0.11	0.03	97.41	1.14	-0.19	0.05	60.61	0.95	-0.19	0.05
L_Hip_Flex_Mom	0.08	0.01	97.91	0.83	-0.16	0.05	61.01	0.98	-0.16	0.05
R_Knee_Rot_Mom	0.01	0.01	63.31	2.84	-0.01	0.01	72.31	14.94	0.00	0.02
L_Knee_Rot_Mom	0.01	0.01	65.11	2.02	-0.02	0.01	62.01	3.17	-0.01	0.02
R_Knee_Abd_Mom	0.06	0.04	65.91	12.46	-0.02	0.01	75.41	11.82	0.05	0.05
L_Knee_Abd_Mom	0.04	0.03	67.61	14.00	-0.02	0.01	69.31	5.81	0.03	0.03
R_Knee_Flex_Mom	0.10	0.03	60.61	0.95	-0.07	0.01	95.91	1.34	0.10	0.03
L_Knee_Flex_Mom	0.11	0.03	61.01	0.98	-0.04	0.01	93.81	3.77	0.11	0.03
R_Ank_Rot_Mom	0.01	0.01	72.41	15.25	-0.01	0.02	63.51	2.97	0.00	0.03
L_Ank_Rot_Mom	0.02	0.01	64.61	8.44	-0.01	0.01	65.11	2.07	0.01	0.02
R_Ank_Abd_Mom	0.03	0.02	60.61	0.95	0.00	0.00	67.01	1.84	0.03	0.02
L_Ank_Abd_Mom	0.02	0.02	66.11	10.89	0.00	0.00	65.71	2.92	0.02	0.02
R_Ank_Flex_Mom	0.13	0.07	60.61	0.95	-0.03	0.00	67.41	1.04	0.13	0.07
L_Ank_Flex_Mom	0.13	0.04	61.01	0.98	-0.02	0.00	67.61	0.95	0.13	0.04
R_Hip_Pwr	0.44	0.17	61.11	0.98	-0.03	0.03	87.71	1.92	0.43	0.18
L_Hip_Pwr	0.41	0.20	61.01	0.98	-0.03	0.02	84.71	5.97	0.41	0.20
R_Knee_Pwr	0.07	0.02	69.61	2.91	-0.82	0.27	63.81	9.45	-0.82	0.27
L_Knee_Pwr	0.10	0.03	69.01	0.97	-0.80	0.21	61.01	0.98	-0.80	0.21
R_Ank_Pwr	0.40	0.29	60.61	0.95	0.00	0.00	87.31	8.48	0.40	0.29
L_Ank_Pwr	0.36	0.17	61.01	0.98	0.00	0.00	86.41	7.51	0.36	0.17

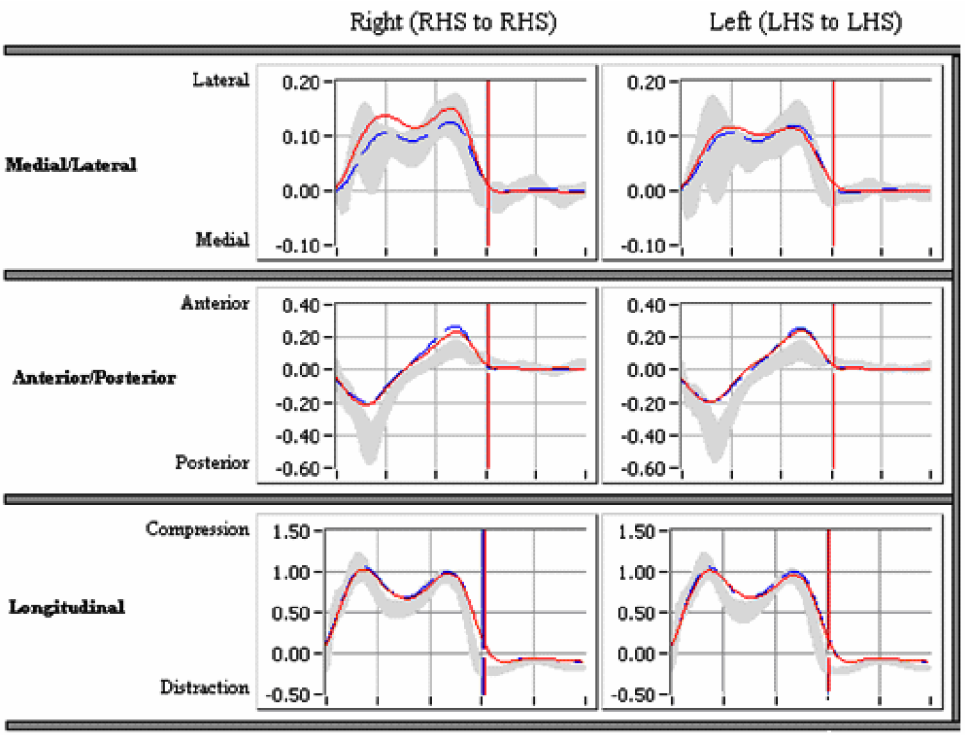

Figure C.17 Hip Joint Forces (N), 8-year-old subjects.

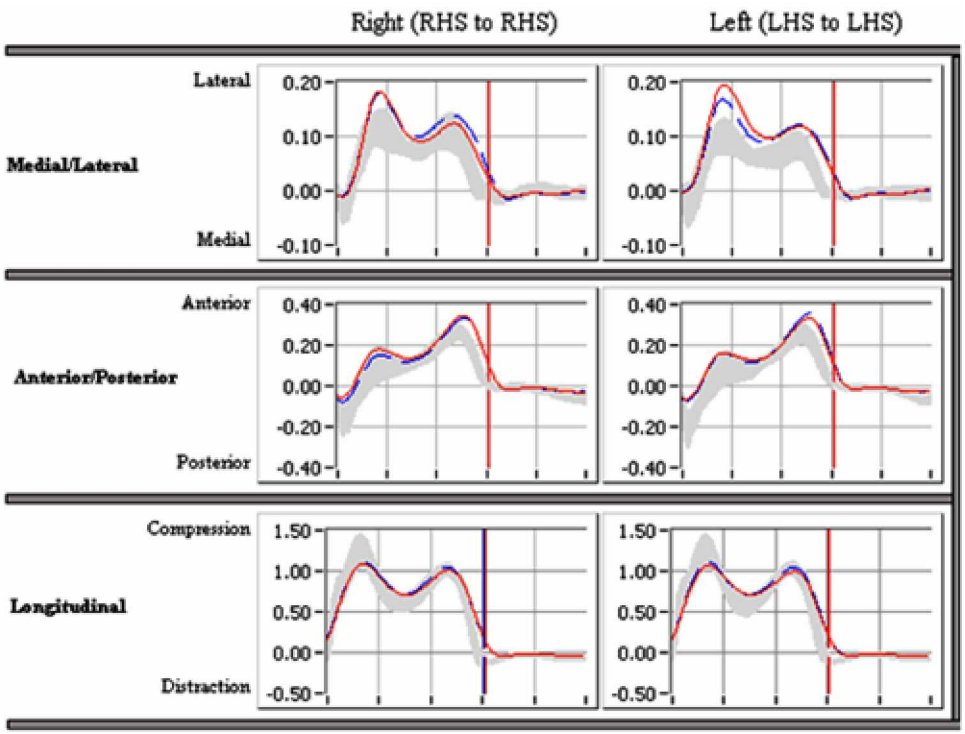

Figure C.18 Knee Joint Forces (N), 8-year-old subjects.

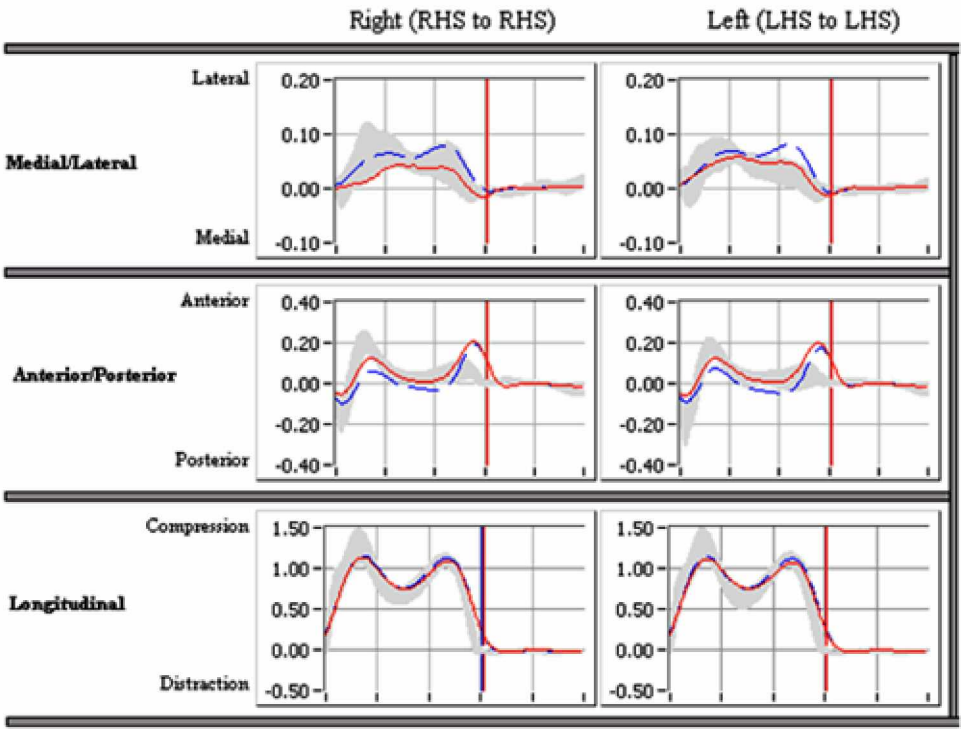

Figure C.19 Ankle Joint Forces (N), 8-year-old subjects.

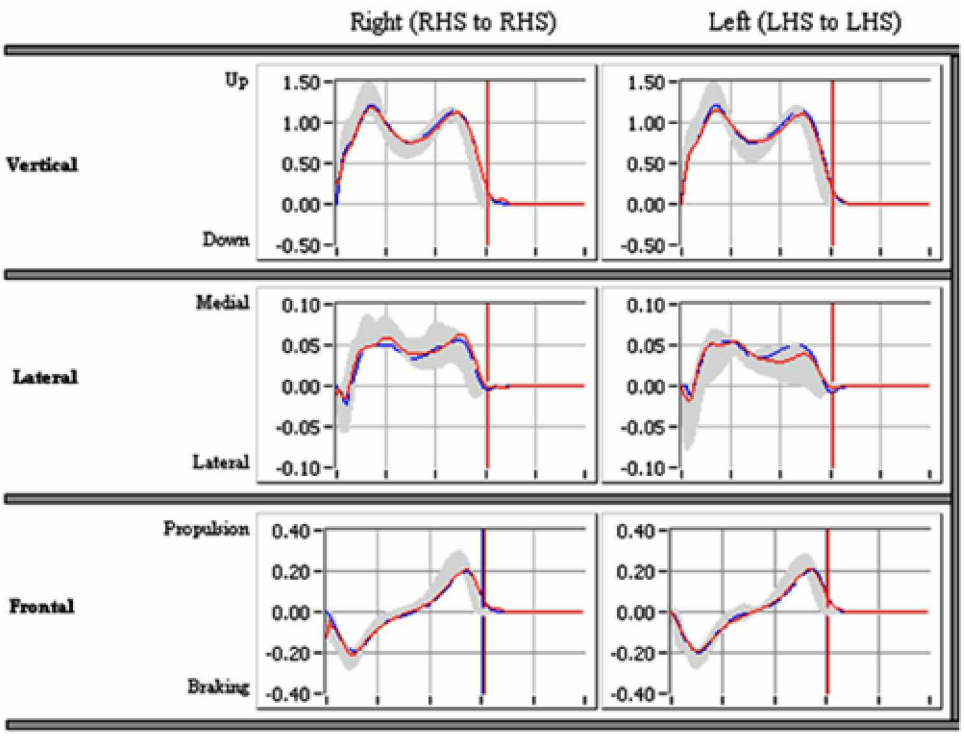

Figure C.20 Ground Reaction Forces (N), 8-year-old subjects.

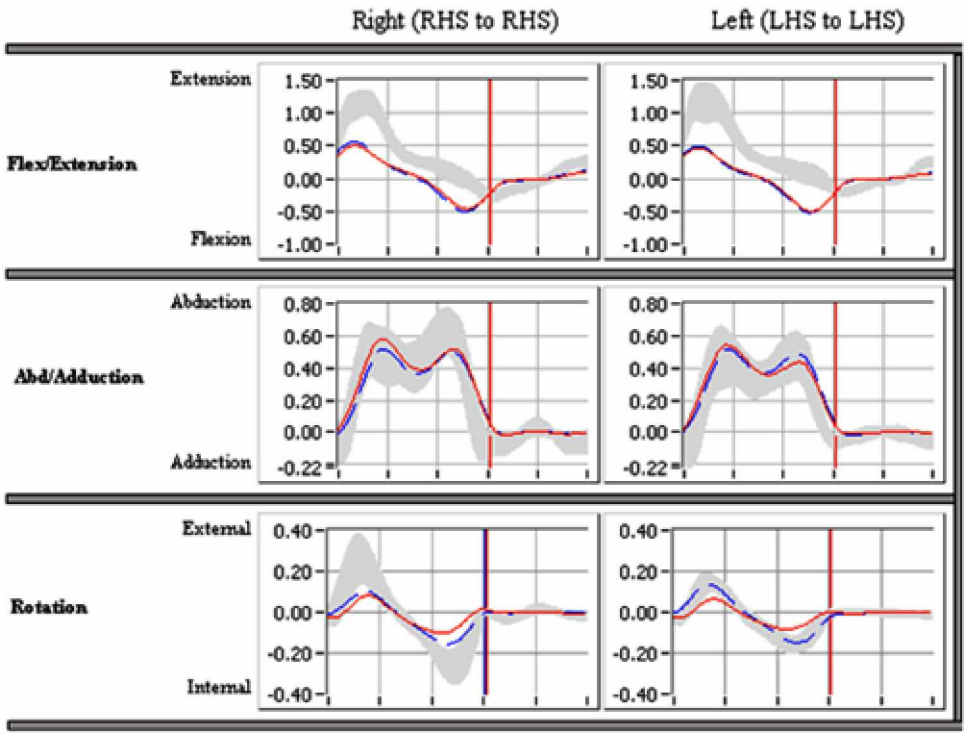

Figure C.21 Hip Joint Moments (Nm/Kg), 8-year-old subjects.

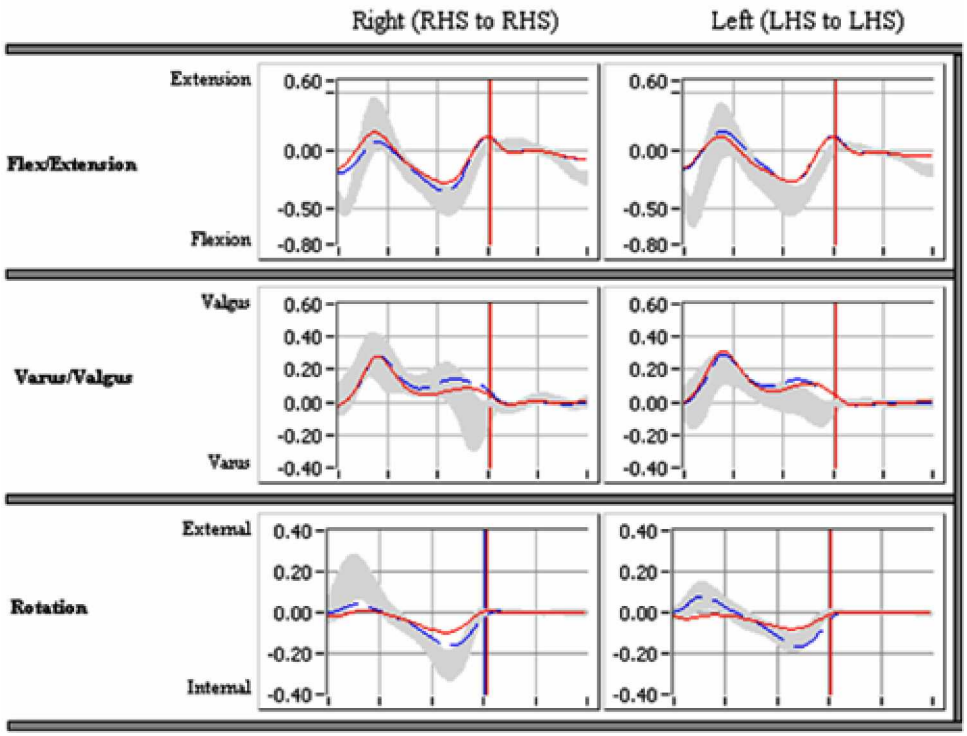

Figure C.22 Knee Joint Moments (Nm/Kg), 8-year-old subjects.

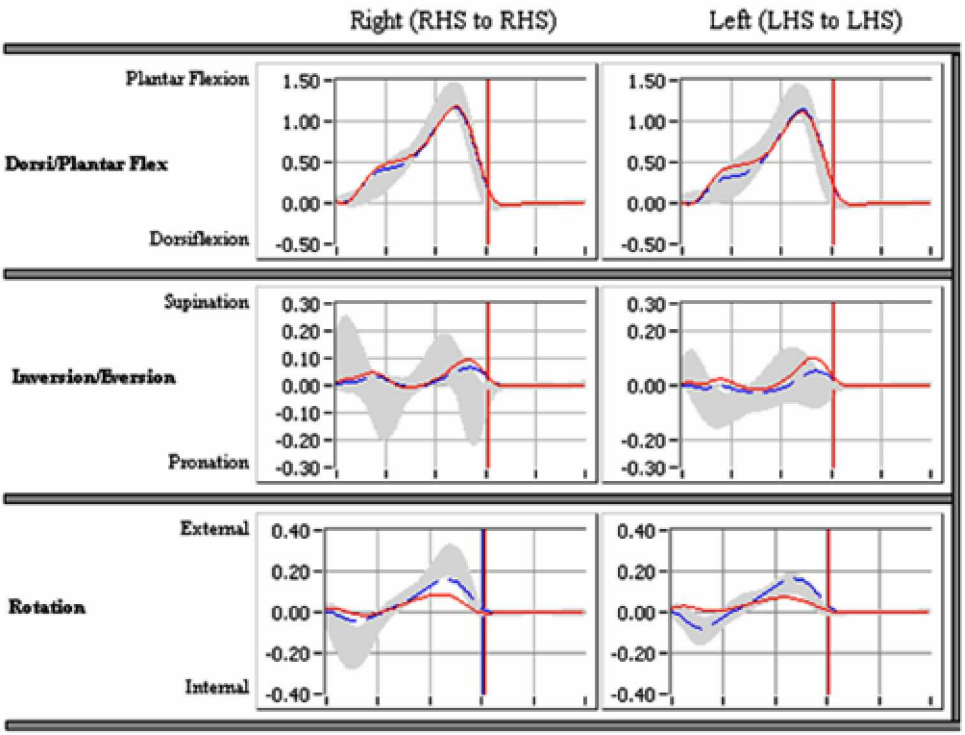

Figure C.23 Ankle Joint Moments (Nm/Kg), 8-year-old subjects.

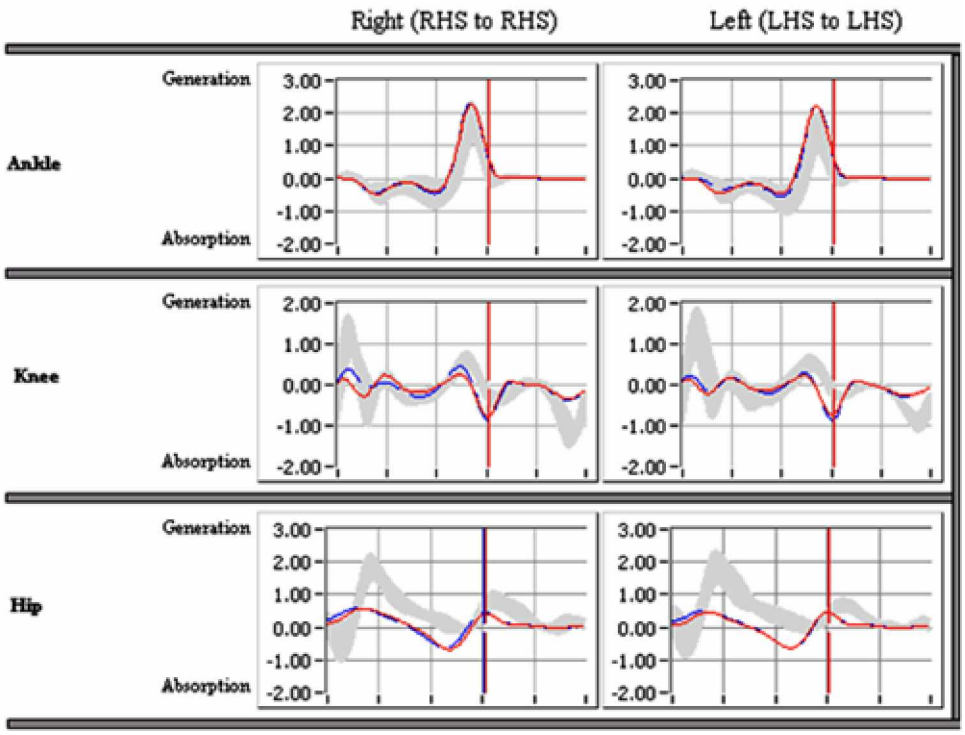

Figure C.24 Sagittal Joint Powers (Watts/Kg), 8-year-old subjects.

Table C.13 Stance Phase Kinetics of 9-year-old Female Subjects.

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	0.22	0.10	2.06	0.12	20.60	13.99	0.09	0.07	54.40	19.15
L_Hip_Rot_Frc	0.24	0.09	2.03	0.17	26.80	16.61	0.15	0.06	47.90	25.26
R_Hip_Abd_Frc	-0.10	0.05	0.47	0.10	46.50	1.18	-0.36	0.15	11.00	1.63
L_Hip_Abd_Frc	-0.10	0.04	0.43	0.09	46.00	1.33	-0.37	0.12	11.10	1.20
R_Hip_Flex_Frc	0.01	0.01	0.29	0.08	30.40	14.44	0.01	0.01	24.10	31.11
L_Hip_Flex_Frc	0.02	0.02	0.28	0.04	40.90	7.28	0.00	0.02	36.20	31.16
R_Knee_Rot_Frc	0.35	0.11	2.17	0.13	20.30	13.87	0.17	0.06	60.50	1.18
L_Knee_Rot_Frc	0.36	0.10	2.14	0.18	17.10	10.63	0.22	0.07	53.90	18.96
R_Knee_Abd_Frc	-0.12	0.03	0.64	0.10	49.60	1.26	-0.14	0.04	2.00	1.33
L_Knee_Abd_Frc	-0.11	0.03	0.66	0.10	49.40	1.17	-0.12	0.04	1.40	0.97
R_Knee_Flex_Frc	0.00	0.02	0.33	0.12	25.50	15.58	-0.01	0.02	18.30	27.82
L_Knee_Flex_Frc	-0.02	0.02	0.30	0.05	25.70	15.42	-0.02	0.02	1.50	1.35
R_Ank_Rot_Frc	0.40	0.11	2.28	0.13	30.10	17.22	0.23	0.06	60.50	1.18
L_Ank_Rot_Frc	0.42	0.10	2.25	0.18	29.80	17.34	0.29	0.07	53.90	18.96
R_Ank_Abd_Frc	-0.12	0.04	0.35	0.11	54.90	1.79	-0.17	0.06	13.80	17.69
L_Ank_Abd_Frc	-0.12	0.04	0.33	0.09	55.20	1.48	-0.17	0.04	18.10	19.73
R_Ank_Flex_Frc	0.01	0.01	0.12	0.05	20.60	11.13	-0.06	0.02	56.20	2.49
L_Ank_Flex_Frc	0.00	0.01	0.10	0.04	27.00	9.53	-0.05	0.03	51.40	16.45
R_GRF_Fwd_Frc	0.00	0.00	0.40	0.07	52.70	1.16	-0.40	0.08	9.50	1.08
L_GRF_Fwd_Frc	0.00	0.00	0.40	0.09	52.60	1.17	-0.39	0.08	9.20	0.63
R_GRF_Lat_Frc	0.00	0.00	0.13	0.03	29.20	17.12	-0.05	0.03	3.40	0.84
L_GRF_Lat_Frc	0.00	0.00	0.11	0.02	16.60	9.59	-0.04	0.04	30.20	29.12
R_GRF_Vrt_Frc	0.00	0.00	2.35	0.17	27.00	17.06	0.00	0.00	0.00	0.00
L_GRF_Vrt_Frc	0.00	0.00	2.32	0.22	26.80	17.44	0.00	0.00	0.00	0.00
R_Hip_Rot_Mom	-0.03	0.03	0.32	0.19	13.40	1.96	-0.35	0.13	46.70	3.95
L_Hip_Rot_Mom	-0.03	0.05	0.26	0.10	25.00	20.28	-0.30	0.10	42.40	13.47
R_Hip_Abd_Mom	0.05	0.08	1.21	0.20	19.40	9.11	0.01	0.05	36.00	30.99
L_Hip_Abd_Mom	0.02	0.07	1.12	0.18	24.80	13.10	-0.01	0.05	24.10	30.90
R_Hip_Flex_Mom	0.73	0.21	0.97	0.28	5.40	2.01	-0.93	0.24	50.00	1.63
L_Hip_Flex_Mom	0.67	0.16	0.90	0.22	5.40	1.71	-0.83	0.17	49.40	0.84
R_Knee_Rot_Mom	-0.01	0.03	0.22	0.19	20.60	19.73	-0.32	0.14	47.00	4.16
L_Knee_Rot_Mom	-0.01	0.05	0.20	0.11	23.70	21.42	-0.32	0.10	40.40	16.97
R_Knee_Abd_Mom	0.00	0.08	0.56	0.22	15.50	1.43	-0.12	0.11	48.10	17.72
L_Knee_Abd_Mom	-0.06	0.07	0.47	0.20	15.80	1.62	-0.08	0.09	15.90	24.94
R_Knee_Flex_Mom	-0.33	0.07	0.34	0.15	27.80	21.79	-0.65	0.22	37.50	13.31
L_Knee_Flex_Mom	-0.27	0.08	0.35	0.17	27.50	22.21	-0.60	0.17	41.10	2.38
R_Ank_Rot_Mom	0.01	0.03	0.31	0.15	39.80	17.76	-0.23	0.19	20.60	19.22
L_Ank_Rot_Mom	0.01	0.05	0.30	0.12	39.70	16.91	-0.21	0.09	23.30	20.52
R_Ank_Abd_Mom	0.02	0.03	0.20	0.17	46.20	16.97	-0.05	0.09	32.90	23.83
L_Ank_Abd_Mom	0.00	0.03	0.20	0.15	52.60	3.60	-0.06	0.07	16.40	12.52
R_Ank_Flex_Mom	0.01	0.04	2.37	0.31	46.60	1.65	-0.08	0.08	3.80	1.23
L_Ank_Flex_Mom	0.03	0.03	2.35	0.22	46.40	1.65	-0.05	0.05	3.60	1.17
R_Hip_Pwr	0.28	0.36	1.10	0.39	32.40	23.15	-1.22	0.51	45.40	1.65
L_Hip_Pwr	0.24	0.35	1.08	0.33	17.40	14.43	-1.00	0.38	45.40	1.96
R_Knee_Pwr	0.10	0.33	0.79	0.32	42.70	12.38	-1.51	0.44	59.00	1.25
L_Knee_Pwr	0.18	0.33	0.75	0.36	34.60	17.83	-1.47	0.64	53.80	15.43
R_Ank_Pwr	0.01	0.03	4.67	1.43	52.50	1.84	-1.23	0.44	29.50	11.41
L_Ank_Pwr	0.02	0.03	4.82	1.22	52.70	1.49	-1.31	0.40	36.60	6.50

Table C.14 Swing Phase Kinetics of 9-year-old Female Subjects.

	Maximum Swing		Time of Max. Sw.		Minimum Swing		Time of Min. Sw.		Toe Off	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	-0.01	0.06	61.11	1.19	-0.22	0.02	69.31	10.35	-0.01	0.06
L_Hip_Rot_Frc	0.03	0.06	60.61	0.95	-0.22	0.02	69.31	10.35	0.03	0.06
R_Hip_Abd_Frc	0.03	0.01	74.01	10.97	0.00	0.01	87.31	13.38	0.02	0.01
L_Hip_Abd_Frc	0.03	0.01	72.11	10.48	0.00	0.01	85.51	13.94	0.02	0.01
R_Hip_Flex_Frc	0.01	0.01	78.61	12.72	-0.01	0.01	84.11	15.04	0.00	0.01
L_Hip_Flex_Frc	0.01	0.01	68.71	12.05	-0.01	0.01	81.41	14.13	0.00	0.01
R_Knee_Rot_Frc	0.07	0.05	61.11	1.19	-0.10	0.01	68.91	8.42	0.07	0.05
L_Knee_Rot_Frc	0.11	0.05	60.61	0.95	-0.10	0.01	68.41	7.54	0.11	0.05
R_Knee_Abd_Frc	0.08	0.03	61.11	1.19	-0.06	0.01	90.31	9.00	0.08	0.03
L_Knee_Abd_Frc	0.10	0.04	60.61	0.95	-0.06	0.01	91.31	9.35	0.10	0.04
R_Knee_Flex_Frc	0.02	0.03	77.51	17.93	-0.02	0.01	68.11	5.85	0.02	0.04
L_Knee_Flex_Frc	0.03	0.01	64.21	11.42	-0.03	0.01	67.01	0.97	0.03	0.01
R_Ank_Rot_Frc	0.13	0.05	61.11	1.19	-0.05	0.01	66.91	1.26	0.13	0.05
L_Ank_Rot_Frc	0.18	0.06	60.61	0.95	-0.05	0.01	67.01	1.35	0.18	0.06
R_Ank_Abd_Frc	0.09	0.04	61.11	1.19	-0.03	0.00	83.91	14.75	0.09	0.04
L_Ank_Abd_Frc	0.11	0.03	60.61	0.95	-0.03	0.01	75.51	14.36	0.11	0.03
R_Ank_Flex_Frc	0.01	0.00	87.41	10.28	-0.02	0.01	61.11	1.19	-0.02	0.01
L_Ank_Flex_Frc	0.01	0.00	88.51	9.37	-0.02	0.01	60.81	1.33	-0.02	0.01
R_GRF_Fwd_Frc	0.03	0.01	61.11	1.19	0.00	0.00	63.71	1.30	0.03	0.01
L_GRF_Fwd_Frc	0.06	0.03	60.61	0.95	0.00	0.00	63.31	1.64	0.06	0.03
R_GRF_Lat_Frc	0.00	0.00	62.71	1.80	0.00	0.01	62.11	1.85	0.00	0.01
L_GRF_Lat_Frc	0.00	0.00	62.81	2.05	0.00	0.00	61.11	1.09	0.00	0.01
R_GRF_Vrt_Frc	0.11	0.05	61.11	1.19	0.00	0.00	63.81	1.33	0.11	0.05
L_GRF_Vrt_Frc	0.15	0.08	60.61	0.95	0.00	0.00	63.31	1.64	0.15	0.08
R_Hip_Rot_Mom	0.01	0.01	72.11	8.88	-0.02	0.01	74.51	16.00	-0.01	0.02
L_Hip_Rot_Mom	0.02	0.02	78.01	10.27	-0.03	0.01	65.41	4.16	-0.01	0.04
R_Hip_Abd_Mom	0.04	0.02	78.41	15.55	-0.03	0.01	67.11	7.84	0.01	0.03
L_Hip_Abd_Mom	0.04	0.05	75.71	13.85	-0.04	0.02	67.81	10.93	0.02	0.06
R_Hip_Flex_Mom	0.21	0.05	96.31	1.89	-0.29	0.07	61.11	1.19	-0.29	0.07
L_Hip_Flex_Mom	0.16	0.05	97.81	0.79	-0.24	0.07	60.61	0.95	-0.24	0.07
R_Knee_Rot_Mom	0.01	0.00	63.41	2.26	-0.01	0.01	75.61	15.97	0.00	0.01
L_Knee_Rot_Mom	0.02	0.01	63.61	2.80	-0.02	0.02	70.71	14.98	-0.01	0.03
R_Knee_Abd_Mom	0.05	0.06	84.91	16.15	-0.03	0.02	72.81	11.88	0.02	0.07
L_Knee_Abd_Mom	0.05	0.03	63.61	9.88	-0.04	0.02	68.91	4.70	0.05	0.04
R_Knee_Flex_Mom	0.16	0.04	61.11	1.19	-0.14	0.02	95.21	1.51	0.16	0.04
L_Knee_Flex_Mom	0.16	0.06	60.61	0.95	-0.09	0.01	92.31	9.49	0.16	0.06
R_Ank_Rot_Mom	0.01	0.01	74.21	17.03	-0.01	0.01	63.11	2.13	0.00	0.02
L_Ank_Rot_Mom	0.02	0.02	71.01	15.51	-0.02	0.02	63.51	2.81	0.01	0.03
R_Ank_Abd_Mom	0.02	0.02	67.11	12.24	-0.01	0.01	64.81	2.35	0.01	0.02
L_Ank_Abd_Mom	0.03	0.02	60.61	0.95	-0.01	0.00	66.11	1.78	0.03	0.02
R_Ank_Flex_Mom	0.12	0.05	61.11	1.19	-0.05	0.01	66.31	1.07	0.12	0.05
L_Ank_Flex_Mom	0.17	0.05	60.61	0.95	-0.05	0.01	66.11	1.19	0.17	0.05
R_Hip_Pwr	0.76	0.24	61.11	1.19	-0.04	0.04	84.91	3.78	0.76	0.24
L_Hip_Pwr	0.58	0.27	60.61	0.95	-0.03	0.04	83.41	6.07	0.58	0.27
R_Knee_Pwr	0.16	0.08	68.51	3.42	-1.12	0.30	63.71	8.48	-1.11	0.33
L_Knee_Pwr	0.20	0.11	67.41	1.14	-1.17	0.50	63.51	9.57	-1.16	0.50
R_Ank_Pwr	0.35	0.24	61.11	1.19	-0.01	0.01	84.91	11.73	0.35	0.24
L_Ank_Pwr	0.50	0.27	60.61	0.95	-0.02	0.01	82.81	13.64	0.50	0.27

Table C.15 Stance Phase Kinetics of 9-year-old Male Subjects.

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	0.18	0.09	1.82	0.64	25.80	17.80	0.12	0.09	42.30	29.20
L_Hip_Rot_Frc	0.18	0.05	2.04	0.09	20.80	13.31	0.12	0.05	36.50	31.42
R_Hip_Abd_Frc	-0.09	0.05	0.44	0.18	41.90	14.81	-0.30	0.14	9.60	3.89
L_Hip_Abd_Frc	-0.11	0.03	0.44	0.09	46.70	0.82	-0.33	0.06	10.70	1.16
R_Hip_Flex_Frc	0.00	0.02	0.23	0.11	31.50	17.53	-0.01	0.02	18.50	28.68
L_Hip_Flex_Frc	0.01	0.01	0.22	0.08	34.20	13.42	-0.01	0.02	24.80	30.98
R_Knee_Rot_Frc	0.29	0.13	1.91	0.68	22.20	16.60	0.18	0.09	48.40	25.53
L_Knee_Rot_Frc	0.31	0.06	2.12	0.09	17.00	10.22	0.20	0.06	54.50	19.17
R_Knee_Abd_Frc	-0.11	0.04	0.61	0.22	45.00	15.85	-0.14	0.06	2.50	1.84
L_Knee_Abd_Frc	-0.12	0.02	0.70	0.08	49.80	0.79	-0.14	0.04	1.80	1.48
R_Knee_Flex_Frc	-0.01	0.01	0.26	0.11	20.80	14.09	-0.02	0.02	1.10	1.45
L_Knee_Flex_Frc	-0.01	0.02	0.31	0.09	26.10	15.43	-0.01	0.03	0.70	0.82
R_Ank_Rot_Frc	0.34	0.14	2.01	0.71	32.20	18.77	0.23	0.11	48.40	25.53
L_Ank_Rot_Frc	0.37	0.06	2.24	0.07	30.10	16.79	0.27	0.06	48.50	25.57
R_Ank_Abd_Frc	-0.10	0.04	0.37	0.13	49.20	17.33	-0.14	0.05	2.30	1.34
L_Ank_Abd_Frc	-0.11	0.03	0.40	0.05	54.80	0.63	-0.14	0.05	2.00	1.25
R_Ank_Flex_Frc	0.00	0.01	0.13	0.09	29.30	15.02	-0.03	0.03	34.60	29.20
L_Ank_Flex_Frc	0.01	0.01	0.16	0.05	21.50	9.31	-0.03	0.03	46.40	24.55
R_GRF_Fwd_Frc	0.00	0.00	0.34	0.12	47.90	16.88	-0.32	0.12	8.20	3.52
L_GRF_Fwd_Frc	0.00	0.00	0.39	0.04	53.20	0.79	-0.37	0.07	9.30	2.06
R_GRF_Lat_Frc	0.00	0.00	0.12	0.05	33.70	19.07	-0.04	0.04	14.60	24.23
L_GRF_Lat_Frc	0.00	0.00	0.12	0.02	20.90	14.58	-0.04	0.04	3.40	0.84
R_GRF_Vrt_Frc	0.00	0.00	2.09	0.74	22.30	17.40	0.00	0.00	0.00	0.00
L_GRF_Vrt_Frc	0.00	0.00	2.32	0.08	23.50	16.01	0.00	0.00	0.00	0.00
R_Hip_Rot_Mom	-0.02	0.03	0.22	0.19	20.70	17.97	-0.28	0.19	36.90	17.23
L_Hip_Rot_Mom	-0.01	0.03	0.23	0.16	17.60	13.33	-0.28	0.12	42.80	12.87
R_Hip_Abd_Mom	-0.02	0.10	0.93	0.38	21.40	14.69	-0.04	0.07	24.20	31.03
L_Hip_Abd_Mom	-0.03	0.08	0.94	0.17	26.40	13.14	-0.06	0.05	18.40	29.40
R_Hip_Flex_Mom	0.68	0.28	0.90	0.37	5.00	2.62	-0.93	0.41	44.90	15.87
L_Hip_Flex_Mom	0.71	0.11	0.98	0.15	5.60	1.78	-0.94	0.28	49.50	1.18
R_Knee_Rot_Mom	-0.01	0.02	0.16	0.18	24.60	22.22	-0.30	0.18	34.40	19.63
L_Knee_Rot_Mom	0.00	0.02	0.16	0.18	16.30	15.05	-0.31	0.11	43.80	12.48
R_Knee_Abd_Mom	-0.04	0.05	0.45	0.28	18.30	12.67	-0.08	0.11	9.30	19.21
L_Knee_Abd_Mom	-0.04	0.07	0.48	0.19	16.10	1.91	-0.08	0.11	10.30	21.73
R_Knee_Flex_Mom	-0.32	0.13	0.30	0.19	39.50	24.92	-0.55	0.28	37.60	13.39
L_Knee_Flex_Mom	-0.31	0.06	0.33	0.10	40.50	22.83	-0.51	0.19	33.70	17.80
R_Ank_Rot_Mom	0.01	0.02	0.31	0.18	34.00	19.43	-0.17	0.18	24.10	21.85
L_Ank_Rot_Mom	0.00	0.02	0.31	0.12	46.20	3.29	-0.16	0.18	20.60	19.95
R_Ank_Abd_Mom	0.00	0.01	0.14	0.14	44.20	19.61	-0.09	0.06	23.70	18.77
L_Ank_Abd_Mom	-0.01	0.01	0.08	0.10	49.40	17.82	-0.13	0.09	23.90	16.84
R_Ank_Flex_Mom	0.01	0.04	2.15	0.77	42.60	15.01	-0.06	0.06	3.80	1.87
L_Ank_Flex_Mom	0.03	0.04	2.37	0.19	47.30	0.67	-0.01	0.06	2.60	1.58
R_Hip_Pwr	0.47	0.54	1.17	0.56	23.40	25.14	-1.17	0.55	40.80	14.47
L_Hip_Pwr	0.51	0.37	1.31	0.33	24.60	23.48	-1.22	0.39	45.20	2.10
R_Knee_Pwr	-0.06	0.44	0.85	0.50	35.90	20.35	-1.63	0.69	50.20	20.74
L_Knee_Pwr	0.04	0.31	0.73	0.33	31.50	21.93	-1.88	0.53	58.80	0.92
R_Ank_Pwr	0.02	0.04	4.07	1.69	47.60	16.74	-1.23	0.54	32.50	13.36
L_Ank_Pwr	0.01	0.04	4.45	1.22	52.90	0.57	-1.42	0.18	30.50	12.81

Table C.16 Swing Phase Kinetics of 9-year-old Male Subjects.

	Maximum Swing		Time of Max. Sw.		Minimum Swing		Time of Min. Sw.		Toe Off	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	0.03	0.07	60.91	1.07	-0.19	0.07	72.21	14.13	0.03	0.07
L_Hip_Rot_Frc	0.02	0.06	61.01	0.98	-0.21	0.01	72.51	13.79	0.02	0.06
R_Hip_Abd_Frc	0.03	0.02	67.51	6.42	0.00	0.01	91.11	12.85	0.02	0.02
L_Hip_Abd_Frc	0.04	0.01	68.61	8.16	0.00	0.01	91.01	12.12	0.02	0.02
R_Hip_Flex_Frc	0.01	0.01	72.61	12.40	0.00	0.01	72.91	16.97	0.00	0.01
L_Hip_Flex_Frc	0.01	0.00	78.91	15.67	-0.01	0.01	69.91	13.24	0.00	0.01
R_Knee_Rot_Frc	0.09	0.07	60.91	1.07	-0.09	0.03	66.01	2.55	0.09	0.07
L_Knee_Rot_Frc	0.10	0.05	61.01	0.98	-0.09	0.01	74.71	14.03	0.10	0.05
R_Knee_Abd_Frc	0.10	0.05	60.91	1.07	-0.06	0.02	90.31	10.88	0.10	0.05
L_Knee_Abd_Frc	0.10	0.03	61.01	0.98	-0.06	0.01	93.91	1.49	0.10	0.03
R_Knee_Flex_Frc	0.03	0.03	64.21	10.02	-0.03	0.01	68.31	7.30	0.03	0.03
L_Knee_Flex_Frc	0.03	0.01	64.71	11.95	-0.03	0.01	67.01	1.08	0.03	0.01
R_Ank_Rot_Frc	0.15	0.08	60.91	1.07	-0.05	0.02	66.71	2.89	0.15	0.08
L_Ank_Rot_Frc	0.16	0.05	61.01	0.98	-0.05	0.00	67.41	1.14	0.16	0.05
R_Ank_Abd_Frc	0.11	0.05	60.91	1.07	-0.03	0.01	80.21	16.21	0.11	0.05
L_Ank_Abd_Frc	0.12	0.03	61.01	0.98	-0.03	0.01	86.51	14.48	0.12	0.03
R_Ank_Flex_Frc	0.01	0.00	80.51	15.06	-0.02	0.01	61.61	1.70	-0.01	0.02
L_Ank_Flex_Frc	0.00	0.00	91.71	6.12	-0.01	0.01	64.51	7.06	-0.01	0.01
R_GRF_Fwd_Frc	0.03	0.03	61.31	1.84	-0.01	0.02	63.21	2.02	0.03	0.03
L_GRF_Fwd_Frc	0.04	0.03	61.01	0.98	0.00	0.00	63.61	1.25	0.04	0.03
R_GRF_Lat_Frc	0.00	0.00	62.21	1.90	0.00	0.00	62.21	2.28	0.00	0.01
L_GRF_Lat_Frc	0.00	0.00	62.61	2.12	-0.01	0.01	61.61	1.06	0.00	0.01
R_GRF_Vrt_Frc	0.10	0.07	61.01	1.18	0.00	0.00	63.41	2.16	0.10	0.07
L_GRF_Vrt_Frc	0.14	0.07	61.01	0.98	0.00	0.00	63.61	1.25	0.14	0.07
R_Hip_Rot_Mom	0.02	0.01	67.11	8.52	-0.02	0.02	64.11	2.91	0.00	0.03
L_Hip_Rot_Mom	0.01	0.01	81.01	6.87	-0.03	0.01	66.41	10.70	-0.02	0.02
R_Hip_Abd_Mom	0.05	0.04	77.71	16.55	-0.04	0.03	71.61	13.06	0.02	0.06
L_Hip_Abd_Mom	0.05	0.03	79.41	14.69	-0.04	0.02	70.51	13.41	0.00	0.06
R_Hip_Flex_Mom	0.22	0.09	93.21	11.88	-0.30	0.14	60.91	1.07	-0.30	0.14
L_Hip_Flex_Mom	0.18	0.04	96.81	1.14	-0.26	0.09	61.01	0.98	-0.26	0.09
R_Knee_Rot_Mom	0.02	0.01	62.71	2.81	-0.01	0.01	72.21	14.59	0.00	0.03
L_Knee_Rot_Mom	0.01	0.00	64.31	1.77	-0.02	0.01	68.91	13.17	-0.01	0.02
R_Knee_Abd_Mom	0.06	0.06	66.21	12.60	-0.03	0.03	76.71	13.94	0.06	0.06
L_Knee_Abd_Mom	0.04	0.02	64.71	11.95	-0.04	0.02	68.01	1.51	0.04	0.03
R_Knee_Flex_Mom	0.18	0.08	60.91	1.07	-0.13	0.05	92.01	11.43	0.18	0.08
L_Knee_Flex_Mom	0.19	0.04	61.01	0.98	-0.10	0.01	94.11	1.78	0.19	0.04
R_Ank_Rot_Mom	0.01	0.01	69.51	12.81	-0.02	0.01	62.81	2.94	0.00	0.03
L_Ank_Rot_Mom	0.02	0.01	69.91	14.80	-0.01	0.00	64.11	1.65	0.01	0.02
R_Ank_Abd_Mom	0.02	0.02	64.71	11.05	-0.01	0.01	64.51	2.73	0.01	0.02
L_Ank_Abd_Mom	0.01	0.01	73.11	14.73	-0.01	0.01	63.11	2.72	0.00	0.02
R_Ank_Flex_Mom	0.15	0.09	60.91	1.07	-0.05	0.02	65.91	2.68	0.15	0.09
L_Ank_Flex_Mom	0.16	0.05	61.01	0.98	-0.05	0.01	66.61	1.06	0.16	0.05
R_Hip_Pwr	0.78	0.42	60.91	1.07	-0.06	0.05	84.01	8.79	0.78	0.42
L_Hip_Pwr	0.69	0.32	61.01	0.98	-0.06	0.05	86.91	2.79	0.69	0.32
R_Knee_Pwr	0.11	0.10	69.71	5.59	-1.36	0.61	63.91	9.08	-1.32	0.66
L_Knee_Pwr	0.18	0.09	67.91	1.42	-1.35	0.43	61.01	0.98	-1.35	0.43
R_Ank_Pwr	0.28	0.21	60.91	1.07	-0.01	0.02	79.81	12.58	0.28	0.21
L_Ank_Pwr	0.38	0.17	61.01	0.98	-0.01	0.01	87.11	8.60	0.38	0.17

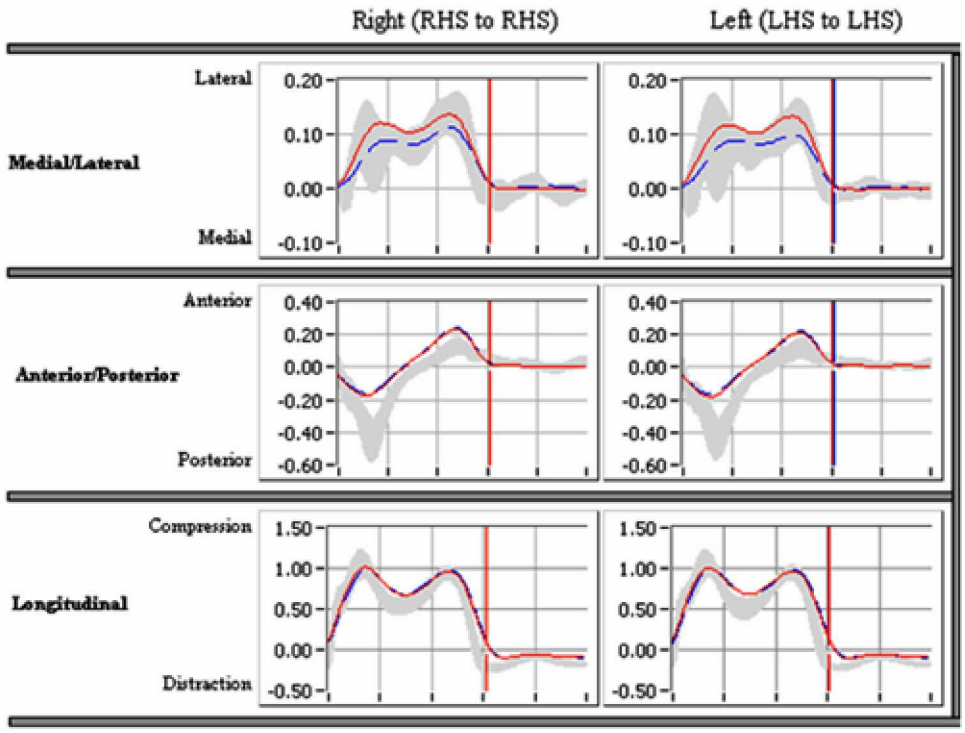

Figure C.25 Hip Joint Forces (N), 9-year-old subjects.

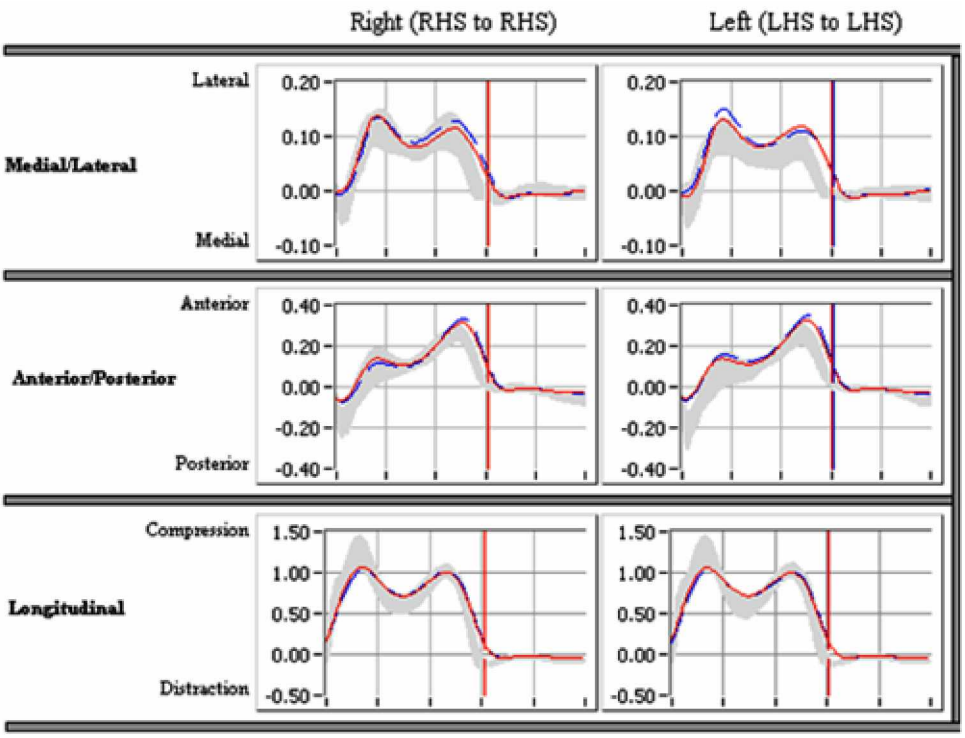

Figure C.26 Knee Joint Forces (N), 9-year-old subjects.

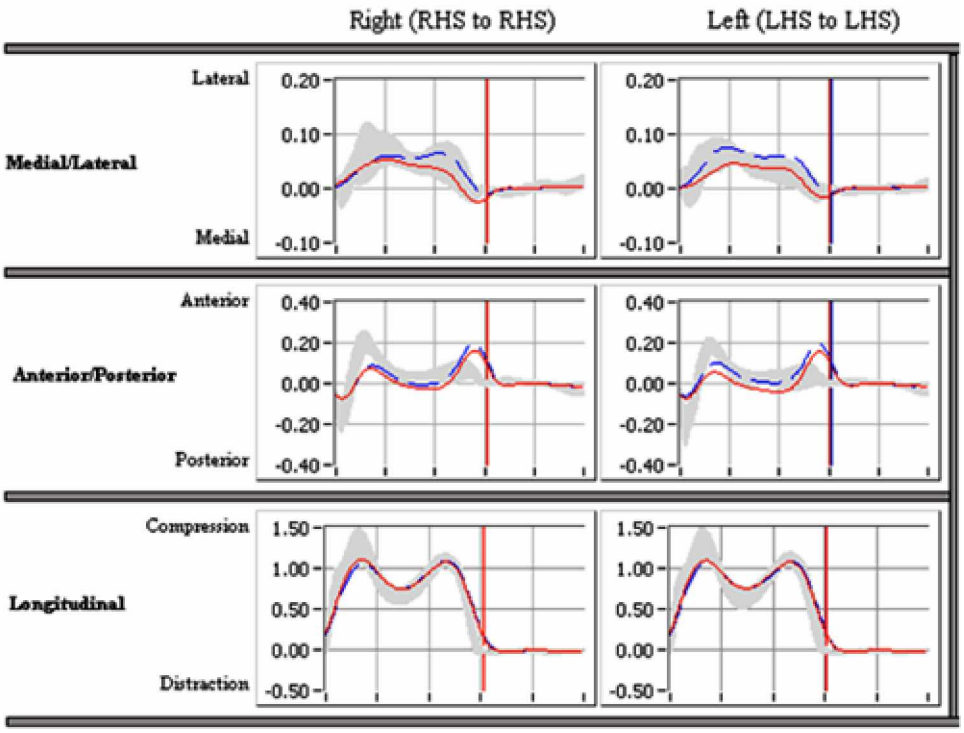

Figure C.27 Ankle Joint Forces (N), 9-year-old subjects.

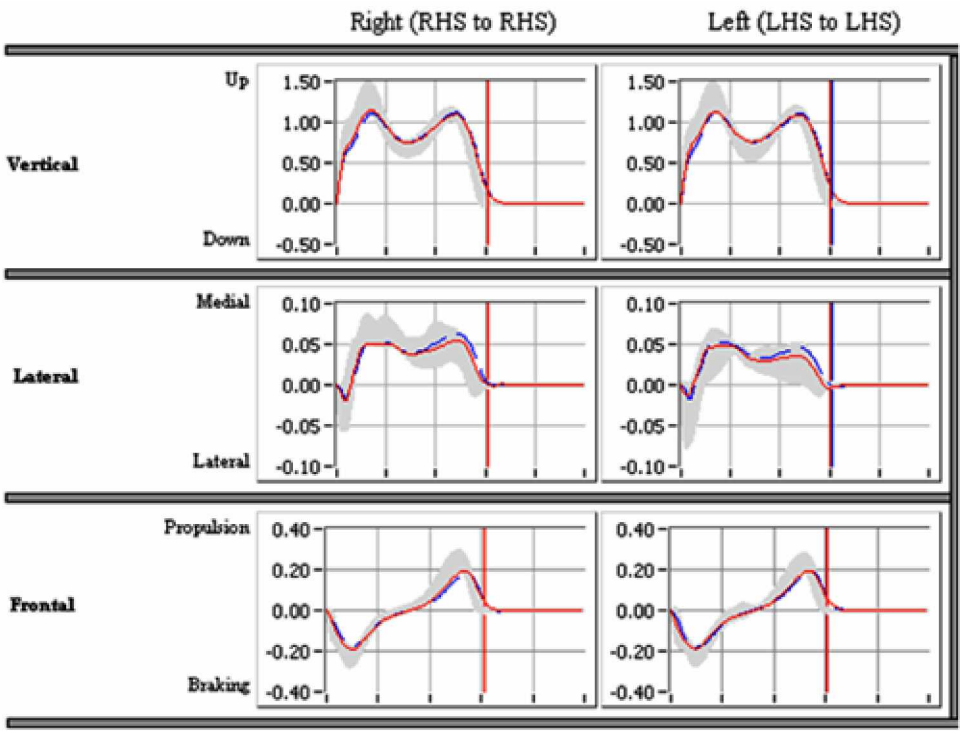

Figure C.28 Ground Reaction Forces (N), 9-year-old subjects.

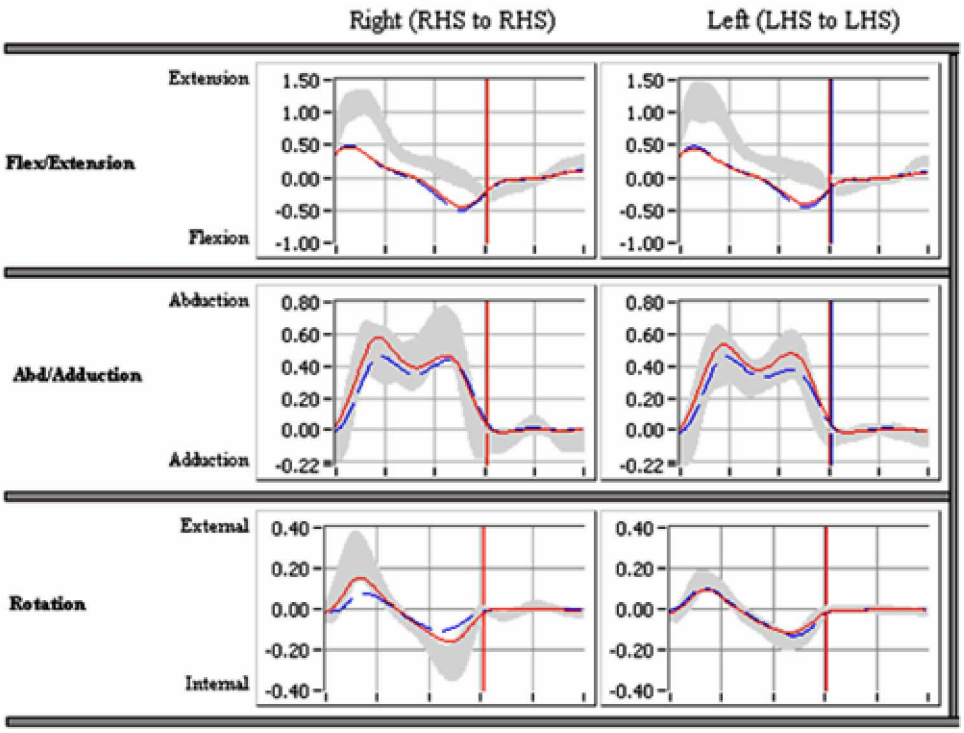

Figure C.29 Hip Joint Moments (Nm/Kg), 9-year-old subjects.

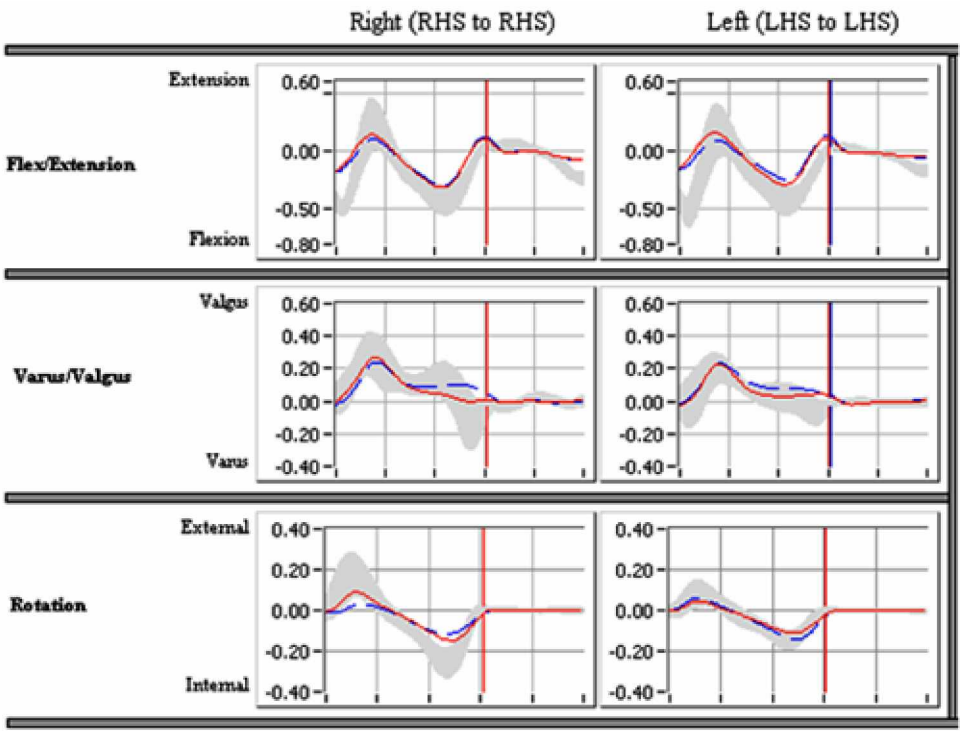

Figure C.30 Knee Joint Moments (Nm/Kg), 9-year-old subjects.

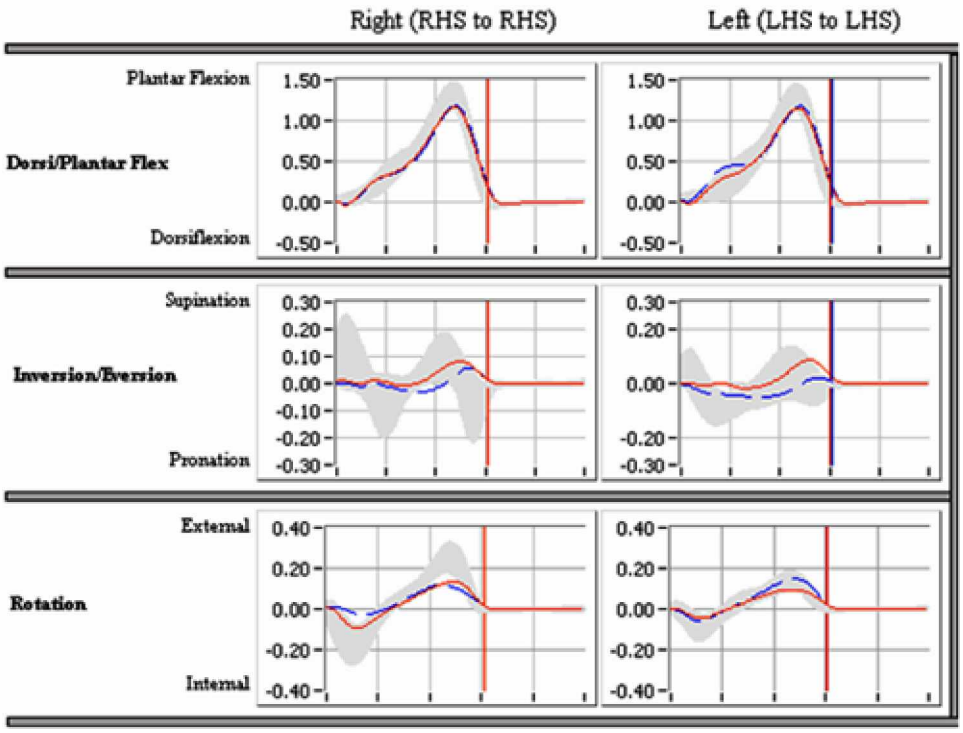

Figure C.31 Ankle Joint Moments (Nm/Kg), 9-year-old subjects.

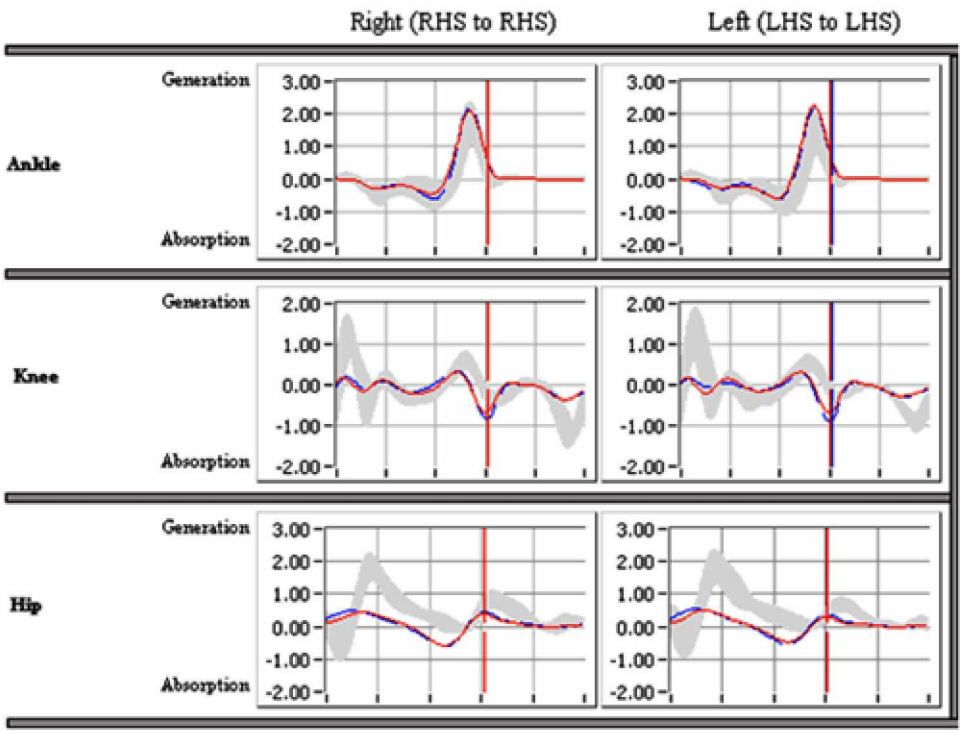

Figure C.32 Sagittal Joint Powers (Watts/Kg), 9-year-old subjects.

Table C.17 Stance Phase Kinetics of 16-year-old Female Subjects.

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	-0.05	0.03	0.91	0.04	40.67	14.02	-0.07	0.03	27.11	32.16
L_Hip_Rot_Frc	-0.05	0.04	0.90	0.04	36.22	15.93	-0.05	0.03	19.89	29.84
R_Hip_Abd_Frc	-0.03	0.02	0.22	0.04	48.00	1.41	-0.13	0.07	11.44	3.68
L_Hip_Abd_Frc	-0.03	0.02	0.23	0.04	47.67	1.32	-0.12	0.06	10.44	4.13
R_Hip_Flex_Frc	-0.01	0.01	0.14	0.03	39.00	13.93	-0.01	0.01	20.56	29.64
L_Hip_Flex_Frc	0.00	0.01	0.11	0.02	41.11	10.25	0.00	0.01	21.33	29.05
R_Knee_Rot_Frc	0.07	0.03	1.00	0.04	40.56	14.23	0.03	0.04	47.44	26.93
L_Knee_Rot_Frc	0.07	0.04	1.00	0.04	32.56	16.91	0.05	0.03	47.00	26.67
R_Knee_Abd_Frc	-0.08	0.02	0.33	0.04	51.00	1.58	-0.08	0.02	1.56	0.73
L_Knee_Abd_Frc	-0.08	0.02	0.29	0.04	50.56	1.13	-0.09	0.02	1.78	0.67
R_Knee_Flex_Frc	0.00	0.01	0.13	0.03	24.00	14.11	-0.01	0.01	21.56	29.10
L_Knee_Flex_Frc	0.00	0.01	0.15	0.02	27.33	15.57	-0.01	0.01	20.67	29.29
R_Ank_Rot_Frc	0.13	0.03	1.10	0.05	44.22	11.00	0.09	0.04	47.44	26.93
L_Ank_Rot_Frc	0.13	0.04	1.08	0.04	40.22	14.03	0.11	0.03	47.00	26.67
R_Ank_Abd_Frc	-0.06	0.01	0.18	0.03	50.89	14.36	-0.07	0.02	1.11	0.78
L_Ank_Abd_Frc	-0.06	0.02	0.15	0.03	55.56	1.33	-0.07	0.02	1.33	0.71
R_Ank_Flex_Frc	0.00	0.01	0.08	0.03	28.00	12.01	-0.02	0.01	46.33	24.63
L_Ank_Flex_Frc	0.00	0.01	0.10	0.03	18.56	2.65	-0.01	0.00	46.22	26.32
R_GRF_Fwd_Frc	0.00	0.00	0.19	0.03	54.44	1.24	-0.17	0.04	10.00	1.32
L_GRF_Fwd_Frc	0.00	0.00	0.19	0.03	53.67	0.87	-0.17	0.04	10.00	0.50
R_GRF_Lat_Frc	0.00	0.00	0.05	0.01	35.00	15.26	-0.04	0.02	3.00	0.00
L_GRF_Lat_Frc	0.00	0.00	0.06	0.01	19.78	11.17	-0.03	0.01	15.56	24.93
R_GRF_Vrt_Frc	0.00	0.00	1.12	0.06	41.00	14.49	0.00	0.00	0.00	0.00
L_GRF_Vrt_Frc	0.00	0.00	1.11	0.04	36.44	16.36	0.00	0.00	0.00	0.00
R_Hip_Rot_Mom	-0.03	0.02	0.16	0.14	29.11	20.48	-0.16	0.10	37.00	18.08
L_Hip_Rot_Mom	-0.01	0.01	0.11	0.07	33.00	23.09	-0.17	0.04	40.33	13.24
R_Hip_Abd_Mom	0.00	0.09	0.76	0.13	28.11	14.88	-0.04	0.07	27.33	32.19
L_Hip_Abd_Mom	-0.01	0.07	0.73	0.11	24.11	13.53	-0.02	0.05	20.33	30.26
R_Hip_Flex_Mom	0.49	0.13	0.54	0.17	1.89	1.83	-0.61	0.15	51.00	1.80
L_Hip_Flex_Mom	0.47	0.11	0.54	0.10	4.67	5.22	-0.55	0.17	50.44	2.01
R_Knee_Rot_Mom	-0.02	0.01	0.10	0.13	37.78	23.38	-0.17	0.10	37.78	18.36
L_Knee_Rot_Mom	-0.01	0.01	0.06	0.05	37.44	24.94	-0.18	0.03	41.78	12.73
R_Knee_Abd_Mom	0.01	0.06	0.39	0.10	17.44	2.13	-0.03	0.04	31.00	30.18
L_Knee_Abd_Mom	-0.01	0.05	0.42	0.09	16.89	2.67	-0.02	0.04	20.22	30.34
R_Knee_Flex_Mom	-0.27	0.06	0.22	0.11	25.11	19.03	-0.33	0.05	28.78	21.72
L_Knee_Flex_Mom	-0.23	0.05	0.14	0.09	39.78	24.02	-0.39	0.09	41.89	2.47
R_Ank_Rot_Mom	0.02	0.01	0.17	0.11	32.78	20.84	-0.11	0.12	37.44	22.85
L_Ank_Rot_Mom	0.01	0.01	0.17	0.04	40.67	12.29	-0.06	0.06	37.11	24.88
R_Ank_Abd_Mom	0.01	0.01	0.11	0.07	43.78	20.95	-0.02	0.04	31.67	19.22
L_Ank_Abd_Mom	0.01	0.01	0.11	0.06	52.89	3.41	-0.01	0.02	21.33	19.09
R_Ank_Flex_Mom	0.00	0.02	1.39	0.12	48.44	1.51	-0.06	0.05	3.33	0.71
L_Ank_Flex_Mom	-0.01	0.01	1.32	0.12	47.56	1.13	-0.07	0.05	3.44	1.01
R_Hip_Pwr	0.16	0.20	0.60	0.14	55.56	15.74	-0.50	0.14	47.00	2.96
L_Hip_Pwr	0.20	0.15	0.51	0.23	16.67	17.08	-0.49	0.17	47.00	3.24
R_Knee_Pwr	0.08	0.17	0.38	0.11	18.67	18.98	-0.79	0.26	59.67	1.87
L_Knee_Pwr	0.07	0.20	0.39	0.16	35.89	21.36	-0.56	0.23	59.78	1.79
R_Ank_Pwr	0.00	0.01	2.61	0.55	54.44	1.74	-0.64	0.18	38.11	4.34
L_Ank_Pwr	-0.01	0.01	2.33	0.55	54.22	1.56	-0.66	0.19	36.89	3.26

Table C.18 Swing Phase Kinetics of 16-year-old Female Subjects.

	Maximum Swing		Time of Max. Sw.		Minimum Swing		Time of Min. Sw.		Toe Off	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	-0.10	0.02	71.29	9.04	-0.20	0.01	76.29	16.80	-0.11	0.03
L_Hip_Rot_Frc	-0.09	0.02	62.94	6.47	-0.20	0.01	76.05	16.95	-0.09	0.03
R_Hip_Abd_Frc	0.04	0.01	71.40	10.38	0.00	0.01	85.95	11.05	0.03	0.01
L_Hip_Abd_Frc	0.04	0.01	71.83	10.55	0.00	0.01	86.05	11.50	0.02	0.01
R_Hip_Flex_Frc	0.00	0.01	70.84	9.95	-0.01	0.01	83.17	13.69	0.00	0.01
L_Hip_Flex_Frc	0.01	0.01	76.61	15.44	-0.01	0.00	80.05	11.93	0.01	0.01
R_Knee_Rot_Frc	-0.01	0.02	69.29	7.13	-0.09	0.01	76.51	13.76	-0.02	0.03
L_Knee_Rot_Frc	0.00	0.03	64.17	7.22	-0.09	0.00	76.61	13.87	0.00	0.03
R_Knee_Abd_Frc	0.03	0.02	61.84	1.41	-0.06	0.01	92.95	2.06	0.03	0.02
L_Knee_Abd_Frc	0.04	0.02	61.05	1.76	-0.06	0.01	93.61	1.00	0.04	0.02
R_Knee_Flex_Frc	0.01	0.01	81.40	19.06	-0.01	0.00	70.40	7.39	0.00	0.01
L_Knee_Flex_Frc	0.01	0.01	70.83	16.28	-0.02	0.00	70.72	8.86	0.01	0.01
R_Ank_Rot_Frc	0.04	0.03	61.84	1.41	-0.04	0.01	66.40	1.41	0.04	0.03
L_Ank_Rot_Frc	0.06	0.03	61.05	1.76	-0.04	0.01	66.17	1.35	0.06	0.03
R_Ank_Abd_Frc	0.04	0.02	61.84	1.41	-0.03	0.00	94.40	1.10	0.04	0.02
L_Ank_Abd_Frc	0.05	0.02	61.05	1.76	-0.03	0.00	94.94	1.00	0.05	0.02
R_Ank_Flex_Frc	0.01	0.00	94.17	3.20	-0.01	0.00	62.84	3.88	-0.01	0.00
L_Ank_Flex_Frc	0.00	0.00	90.50	10.90	0.00	0.00	65.05	6.35	0.00	0.00
R_GRF_Fwd_Frc	0.01	0.01	61.84	1.41	0.00	0.00	64.06	1.68	0.01	0.01
L_GRF_Fwd_Frc	0.02	0.01	61.05	1.76	0.00	0.00	63.72	1.85	0.02	0.01
R_GRF_Lat_Frc	0.00	0.00	63.17	1.14	0.00	0.00	61.95	1.59	0.00	0.00
L_GRF_Lat_Frc	0.00	0.00	63.28	1.89	0.00	0.00	61.28	2.20	0.00	0.00
R_GRF_Vrt_Frc	0.05	0.02	61.84	1.41	0.00	0.00	64.06	1.68	0.05	0.02
L_GRF_Vrt_Frc	0.07	0.02	61.05	1.76	0.00	0.00	63.83	1.87	0.07	0.02
R_Hip_Rot_Mom	0.01	0.01	76.95	12.20	-0.02	0.01	78.06	14.53	0.00	0.02
L_Hip_Rot_Mom	0.02	0.01	65.39	8.94	-0.02	0.01	71.28	5.81	0.01	0.02
R_Hip_Abd_Mom	0.06	0.03	81.95	18.60	-0.06	0.02	77.62	13.29	0.00	0.05
L_Hip_Abd_Mom	0.06	0.03	72.17	17.12	-0.05	0.02	78.61	11.52	0.04	0.03
R_Hip_Flex_Mom	0.27	0.05	95.40	1.48	-0.25	0.07	62.51	2.03	-0.25	0.07
L_Hip_Flex_Mom	0.23	0.06	96.05	0.88	-0.18	0.06	61.94	3.05	-0.17	0.07
R_Knee_Rot_Mom	0.01	0.00	64.06	4.05	-0.01	0.01	83.06	15.92	0.00	0.02
L_Knee_Rot_Mom	0.01	0.01	64.05	4.96	-0.01	0.01	86.17	14.35	0.00	0.02
R_Knee_Abd_Mom	0.04	0.03	83.06	15.51	-0.03	0.01	77.51	12.42	0.01	0.04
L_Knee_Abd_Mom	0.03	0.02	70.17	15.38	-0.03	0.01	76.94	7.83	0.03	0.03
R_Knee_Flex_Mom	0.09	0.04	61.84	1.41	-0.19	0.03	94.40	1.09	0.09	0.04
L_Knee_Flex_Mom	0.07	0.03	61.05	1.76	-0.12	0.03	94.94	0.70	0.07	0.03
R_Ank_Rot_Mom	0.01	0.01	83.40	16.14	-0.01	0.01	63.84	3.81	0.00	0.02
L_Ank_Rot_Mom	0.01	0.01	86.61	14.65	-0.01	0.01	64.05	4.40	0.00	0.02
R_Ank_Abd_Mom	0.01	0.01	68.51	12.38	-0.01	0.00	64.51	2.21	0.01	0.01
L_Ank_Abd_Mom	0.02	0.01	64.28	10.74	0.00	0.00	66.17	2.01	0.02	0.01
R_Ank_Flex_Mom	0.06	0.04	61.84	1.41	-0.04	0.01	65.95	1.74	0.06	0.04
L_Ank_Flex_Mom	0.07	0.04	61.05	1.76	-0.03	0.01	65.72	1.63	0.07	0.04
R_Hip_Pwr	0.60	0.17	64.40	2.65	-0.02	0.03	85.06	4.01	0.56	0.18
L_Hip_Pwr	0.44	0.16	68.72	10.50	-0.02	0.02	86.50	4.23	0.34	0.16
R_Knee_Pwr	0.08	0.08	74.17	10.74	-0.99	0.18	87.62	10.59	-0.56	0.28
L_Knee_Pwr	0.11	0.11	71.17	10.69	-0.73	0.19	81.72	12.91	-0.46	0.19
R_Ank_Pwr	0.15	0.10	62.51	2.03	-0.02	0.01	74.17	11.62	0.15	0.10
L_Ank_Pwr	0.23	0.16	61.05	1.76	-0.02	0.02	76.39	11.51	0.23	0.16

Table C.19 Stance Phase Kinetics of 16-year-old Male Subjects.

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	-0.04	0.02	0.87	0.03	30.60	16.46	-0.07	0.03	24.20	31.25
L_Hip_Rot_Frc	-0.06	0.02	0.86	0.04	36.70	15.25	-0.09	0.02	48.40	25.51
R_Hip_Abd_Frc	-0.03	0.01	0.23	0.04	47.60	0.97	-0.12	0.04	10.30	3.27
L_Hip_Abd_Frc	-0.04	0.02	0.22	0.03	46.90	1.10	-0.10	0.03	9.60	4.01
R_Hip_Flex_Frc	0.00	0.01	0.10	0.03	44.20	2.30	0.00	0.01	14.10	24.26
L_Hip_Flex_Frc	0.01	0.01	0.09	0.03	40.60	8.67	0.00	0.01	35.30	28.56
R_Knee_Rot_Frc	0.08	0.02	0.97	0.03	36.90	15.59	0.03	0.03	42.50	29.34
L_Knee_Rot_Frc	0.06	0.02	0.96	0.04	36.70	15.25	0.01	0.03	54.60	19.20
R_Knee_Abd_Frc	-0.08	0.01	0.30	0.04	50.80	1.23	-0.09	0.02	1.70	0.67
L_Knee_Abd_Frc	-0.08	0.01	0.29	0.04	50.40	0.70	-0.09	0.02	2.00	0.67
R_Knee_Flex_Frc	0.03	0.01	0.12	0.04	24.50	15.45	-0.01	0.01	47.70	24.16
L_Knee_Flex_Frc	0.03	0.01	0.11	0.02	25.20	14.85	-0.01	0.01	59.70	1.25
R_Ank_Rot_Frc	0.13	0.02	1.05	0.04	43.70	10.49	0.09	0.03	42.50	29.34
L_Ank_Rot_Frc	0.12	0.02	1.04	0.05	46.50	1.08	0.07	0.03	54.60	19.20
R_Ank_Abd_Frc	-0.07	0.01	0.16	0.04	51.20	13.48	-0.07	0.02	1.40	0.70
L_Ank_Abd_Frc	-0.07	0.01	0.16	0.03	46.60	17.75	-0.08	0.01	1.40	0.70
R_Ank_Flex_Frc	0.02	0.01	0.09	0.04	28.20	14.09	-0.02	0.01	58.10	1.45
L_Ank_Flex_Frc	0.01	0.01	0.09	0.03	21.90	10.52	-0.01	0.01	58.90	1.91
R_GRF_Fwd_Frc	0.00	0.00	0.16	0.02	54.10	0.88	-0.15	0.02	8.80	2.25
L_GRF_Fwd_Frc	0.00	0.00	0.18	0.02	53.40	0.70	-0.13	0.01	8.50	2.27
R_GRF_Lat_Frc	0.00	0.00	0.08	0.02	48.50	2.88	-0.06	0.01	2.90	0.32
L_GRF_Lat_Frc	0.00	0.00	0.06	0.02	38.70	14.57	-0.04	0.02	3.00	0.00
R_GRF_Vrt_Frc	0.00	0.00	1.08	0.05	40.80	14.16	0.00	0.00	0.00	0.00
L_GRF_Vrt_Frc	0.00	0.00	1.06	0.05	37.00	15.93	0.00	0.00	0.00	0.00
R_Hip_Rot_Mom	-0.01	0.02	0.07	0.06	16.20	15.05	-0.15	0.05	46.20	2.57
L_Hip_Rot_Mom	0.01	0.01	0.06	0.04	19.90	20.67	-0.19	0.05	45.10	4.28
R_Hip_Abd_Mom	0.02	0.04	0.64	0.09	33.70	15.26	-0.01	0.03	36.50	31.21
L_Hip_Abd_Mom	0.01	0.06	0.58	0.07	37.20	12.75	-0.03	0.05	30.50	31.94
R_Hip_Flex_Mom	0.58	0.10	0.60	0.11	1.50	1.35	-0.64	0.15	50.20	1.32
L_Hip_Flex_Mom	0.56	0.10	0.58	0.12	2.50	3.21	-0.59	0.16	49.40	0.97
R_Knee_Rot_Mom	-0.03	0.01	0.04	0.03	30.50	25.00	-0.17	0.06	42.80	12.38
L_Knee_Rot_Mom	-0.01	0.01	0.02	0.02	29.60	25.62	-0.21	0.04	45.30	4.11
R_Knee_Abd_Mom	0.12	0.06	0.39	0.12	23.30	13.39	-0.04	0.05	59.00	2.75
L_Knee_Abd_Mom	0.08	0.03	0.35	0.10	18.20	8.75	-0.03	0.07	53.10	18.91
R_Knee_Flex_Mom	-0.30	0.05	0.21	0.06	27.70	21.64	-0.41	0.10	30.60	21.20
L_Knee_Flex_Mom	-0.28	0.05	0.13	0.05	49.80	18.90	-0.39	0.10	33.30	17.67
R_Ank_Rot_Mom	0.03	0.01	0.16	0.05	42.30	12.22	-0.04	0.03	30.50	24.58
L_Ank_Rot_Mom	0.01	0.01	0.21	0.04	44.80	4.05	-0.02	0.02	29.40	25.38
R_Ank_Abd_Mom	0.01	0.01	0.13	0.04	52.40	2.27	-0.03	0.03	25.10	12.29
L_Ank_Abd_Mom	0.01	0.01	0.09	0.06	43.90	19.75	-0.04	0.04	21.10	12.60
R_Ank_Flex_Mom	-0.02	0.02	1.45	0.13	48.30	1.06	-0.08	0.02	3.40	0.84
L_Ank_Flex_Mom	-0.01	0.01	1.40	0.15	47.70	1.16	-0.07	0.02	3.20	0.42
R_Hip_Pwr	0.08	0.27	0.69	0.12	45.70	23.53	-0.49	0.10	46.40	1.26
L_Hip_Pwr	0.18	0.17	0.60	0.20	34.80	26.28	-0.44	0.09	46.40	1.43
R_Knee_Pwr	0.30	0.27	0.57	0.33	29.90	24.11	-0.72	0.28	54.80	16.12
L_Knee_Pwr	0.27	0.20	0.61	0.29	25.80	24.28	-0.65	0.30	59.20	1.14
R_Ank_Pwr	-0.01	0.01	2.29	0.49	54.20	1.14	-0.59	0.19	39.80	4.44
L_Ank_Pwr	-0.01	0.01	2.32	0.55	54.30	0.82	-0.66	0.16	37.20	4.26

Table C.20 Swing Phase Kinetics of 16-year-old Male Subjects.

	Maximum Swing		Time of Max. Sw.		Minimum Swing		Time of Min. Sw.		Toe Off	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	-0.09	0.03	65.51	7.27	-0.19	0.01	90.71	14.18	-0.10	0.03
L_Hip_Rot_Frc	-0.11	0.01	71.11	6.87	-0.19	0.00	88.31	16.59	-0.13	0.02
R_Hip_Abd_Frc	0.04	0.01	67.41	10.15	0.00	0.01	90.11	9.88	0.03	0.01
L_Hip_Abd_Frc	0.03	0.01	66.81	10.12	-0.01	0.01	88.41	11.10	0.03	0.01
R_Hip_Flex_Frc	0.02	0.01	91.61	8.89	0.00	0.01	74.31	12.84	0.01	0.00
L_Hip_Flex_Frc	0.02	0.01	94.71	8.30	0.00	0.01	69.31	8.84	0.00	0.01
R_Knee_Rot_Frc	0.00	0.03	65.01	6.22	-0.09	0.00	89.81	1.75	-0.01	0.03
L_Knee_Rot_Frc	-0.02	0.01	68.31	6.27	-0.09	0.00	90.21	1.07	-0.03	0.02
R_Knee_Abd_Frc	0.04	0.02	61.21	0.98	-0.05	0.01	93.21	1.71	0.04	0.02
L_Knee_Abd_Frc	0.02	0.01	61.21	0.71	-0.05	0.00	93.31	1.64	0.02	0.01
R_Knee_Flex_Frc	0.03	0.01	93.11	11.46	-0.01	0.01	67.21	7.74	-0.01	0.01
L_Knee_Flex_Frc	0.02	0.01	97.01	1.07	-0.02	0.01	66.01	6.70	-0.01	0.01
R_Ank_Rot_Frc	0.05	0.04	61.21	0.98	-0.04	0.00	67.61	6.74	0.05	0.04
L_Ank_Rot_Frc	0.03	0.02	62.31	3.69	-0.04	0.00	65.21	0.85	0.03	0.02
R_Ank_Abd_Frc	0.04	0.02	61.21	0.98	-0.03	0.00	94.91	0.82	0.04	0.02
L_Ank_Abd_Frc	0.03	0.01	61.21	0.71	-0.03	0.00	94.71	0.56	0.03	0.01
R_Ank_Flex_Frc	0.01	0.00	95.71	0.74	-0.01	0.00	61.21	0.98	-0.01	0.00
L_Ank_Flex_Frc	0.01	0.00	95.61	1.41	-0.01	0.00	64.21	4.72	-0.01	0.00
R_GRF_Fwd_Frc	0.02	0.02	61.21	0.98	0.00	0.00	63.51	1.38	0.02	0.02
L_GRF_Fwd_Frc	0.01	0.01	61.81	1.23	0.00	0.00	63.21	1.18	0.01	0.01
R_GRF_Lat_Frc	0.00	0.00	61.71	1.00	0.00	0.00	62.51	1.67	0.00	0.00
L_GRF_Lat_Frc	0.00	0.00	62.71	1.00	0.00	0.00	61.81	1.23	0.00	0.00
R_GRF_Vrt_Frc	0.05	0.03	61.21	0.98	0.00	0.00	63.71	1.00	0.05	0.03
L_GRF_Vrt_Frc	0.04	0.02	61.21	0.71	0.00	0.00	63.61	0.94	0.04	0.02
R_Hip_Rot_Mom	0.01	0.01	83.71	7.57	-0.02	0.01	73.51	15.29	-0.01	0.01
L_Hip_Rot_Mom	0.01	0.00	81.41	8.65	-0.02	0.01	68.71	10.56	-0.01	0.01
R_Hip_Abd_Mom	0.10	0.03	96.51	6.29	-0.03	0.02	65.21	3.69	-0.01	0.02
L_Hip_Abd_Mom	0.08	0.03	97.31	4.11	-0.03	0.03	70.41	8.97	-0.02	0.04
R_Hip_Flex_Mom	0.36	0.06	95.71	0.74	-0.30	0.06	61.21	0.98	-0.30	0.06
L_Hip_Flex_Mom	0.29	0.05	95.61	0.66	-0.18	0.04	63.41	7.13	-0.18	0.05
R_Knee_Rot_Mom	0.01	0.00	62.31	1.57	-0.01	0.00	93.81	1.48	0.01	0.01
L_Knee_Rot_Mom	0.01	0.00	65.21	4.53	-0.01	0.00	90.41	10.57	0.00	0.01
R_Knee_Abd_Mom	0.11	0.03	97.41	1.03	-0.04	0.02	66.91	10.73	-0.03	0.03
L_Knee_Abd_Mom	0.06	0.02	96.91	1.16	-0.04	0.01	71.61	8.23	-0.02	0.02
R_Knee_Flex_Mom	0.10	0.03	61.21	0.98	-0.19	0.02	95.11	0.85	0.10	0.03
L_Knee_Flex_Mom	0.07	0.02	61.21	0.71	-0.13	0.01	95.01	0.51	0.07	0.02
R_Ank_Rot_Mom	0.01	0.00	91.11	10.50	-0.01	0.00	62.41	1.40	-0.01	0.01
L_Ank_Rot_Mom	0.01	0.00	87.61	14.32	-0.01	0.00	67.11	4.60	0.00	0.01
R_Ank_Abd_Mom	0.01	0.01	70.91	16.16	0.00	0.00	64.51	1.10	0.01	0.01
L_Ank_Abd_Mom	0.01	0.00	74.91	18.05	0.00	0.00	64.31	0.68	0.01	0.00
R_Ank_Flex_Mom	0.08	0.06	61.21	0.98	-0.04	0.00	65.41	0.93	0.08	0.06
L_Ank_Flex_Mom	0.04	0.03	64.81	11.55	-0.04	0.01	65.01	0.85	0.04	0.03
R_Hip_Pwr	0.66	0.16	62.61	2.36	-0.04	0.08	89.01	4.55	0.64	0.17
L_Hip_Pwr	0.47	0.14	62.81	2.78	-0.02	0.03	88.71	4.23	0.42	0.15
R_Knee_Pwr	0.05	0.04	78.31	11.50	-0.87	0.24	91.91	0.95	-0.59	0.23
L_Knee_Pwr	0.09	0.07	76.41	15.47	-0.63	0.13	90.81	1.32	-0.40	0.12
R_Ank_Pwr	0.18	0.15	61.81	2.54	-0.01	0.00	83.91	6.85	0.18	0.16
L_Ank_Pwr	0.12	0.06	61.71	1.86	-0.02	0.01	77.11	11.64	0.12	0.07

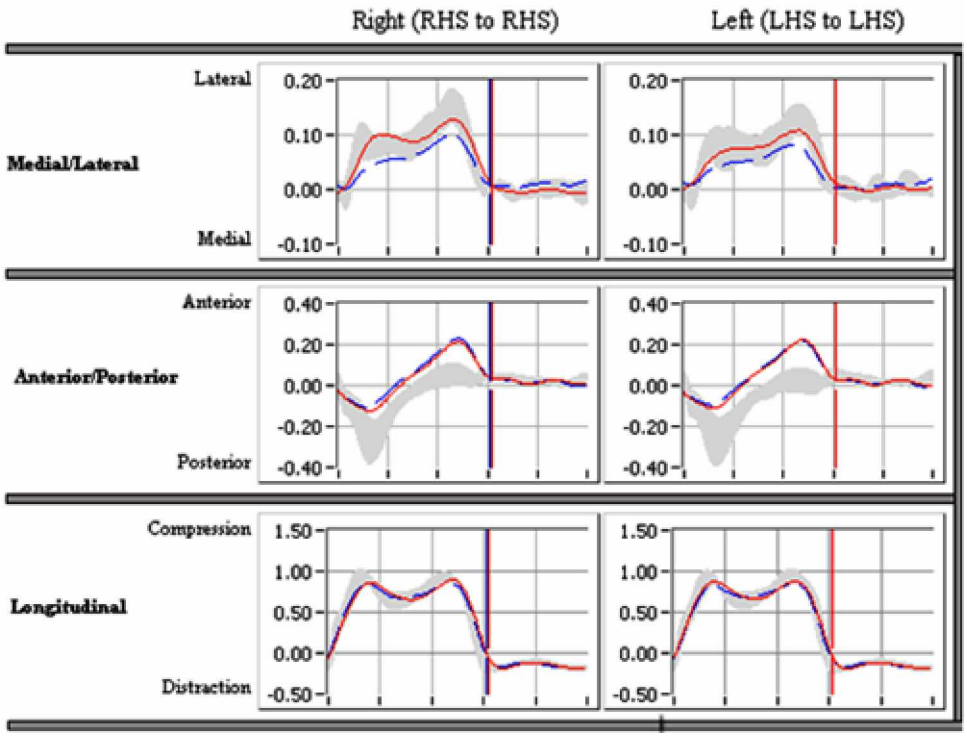

Figure C.33 Hip Joint Forces (N), 16-year-old subjects.

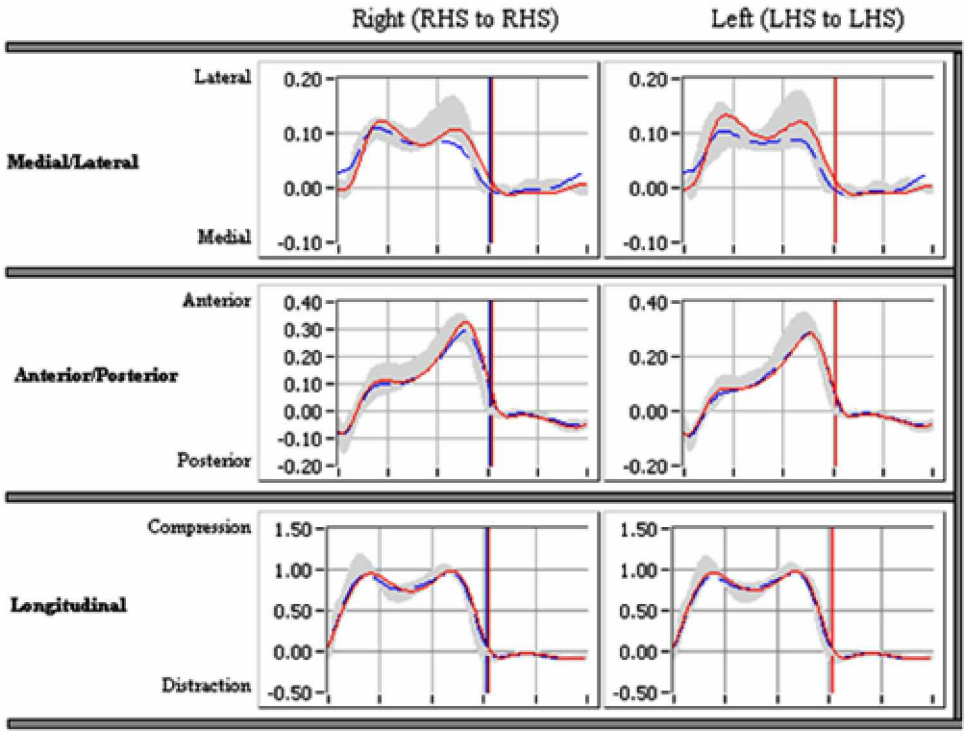

Figure C.34 Knee Joint Forces (N), 16-year-old subjects.

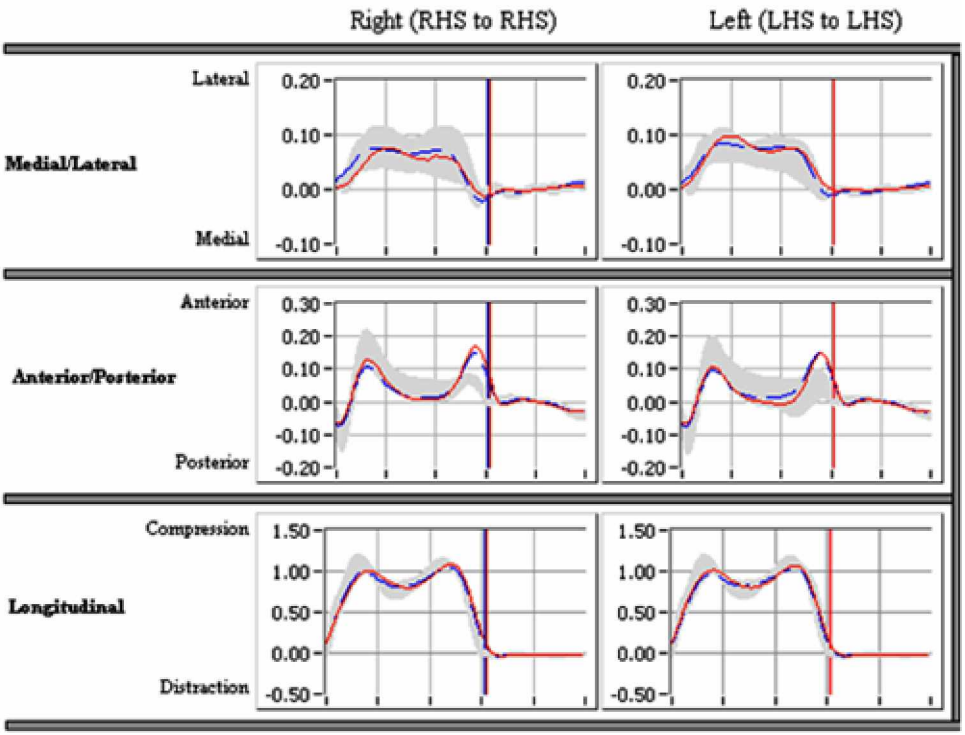

Figure C.35 Ankle Joint Forces (N), 16-year-old subjects.

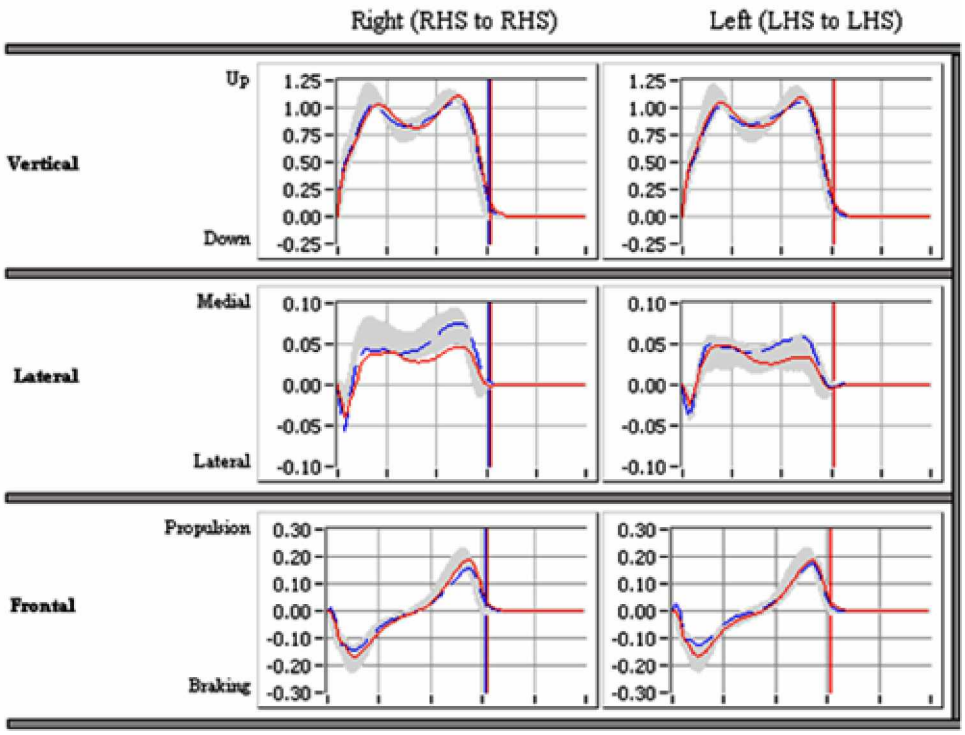

Figure C.36 Ground Reaction Forces (N), 16-year-old subjects.

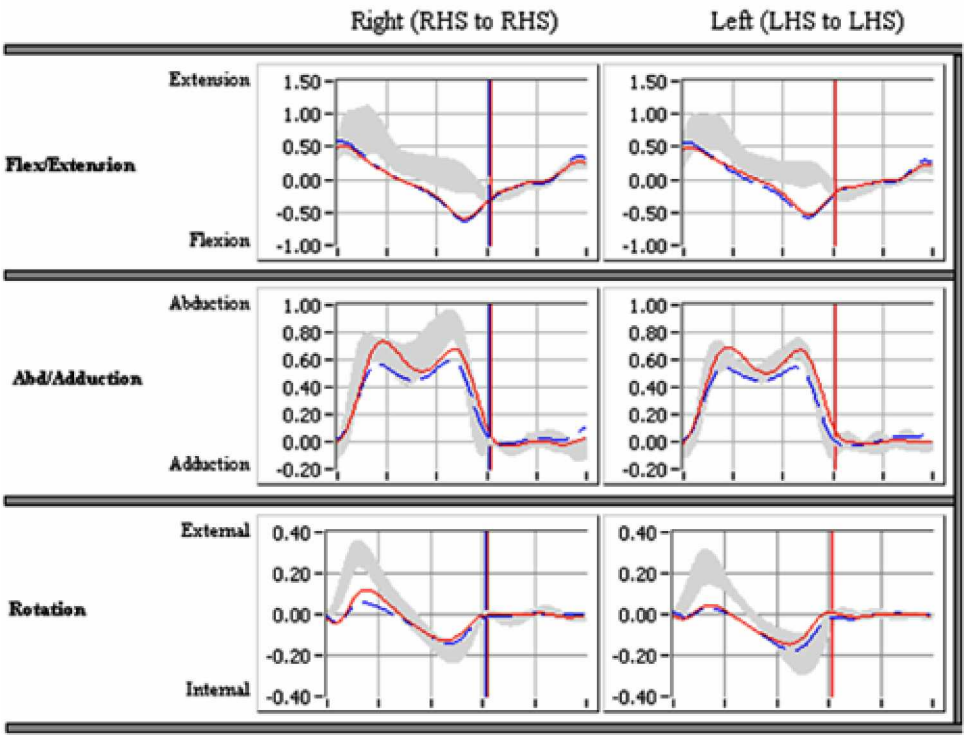

Figure C.37 Hip Joint Moments (Nm/Kg), 16-year-old subjects.

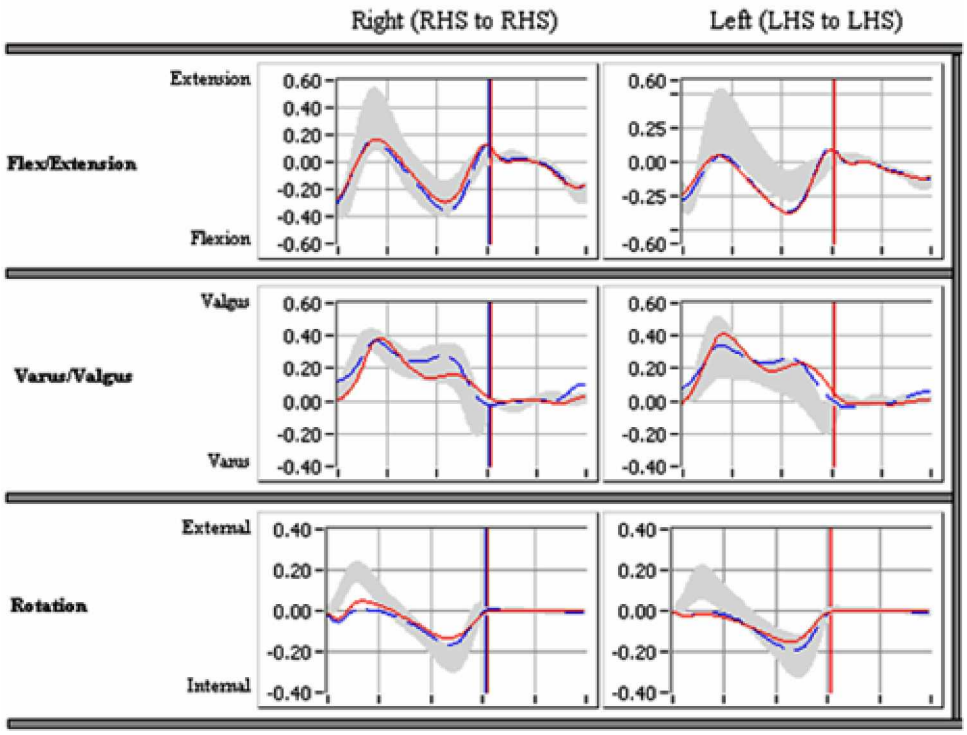

Figure C.38 Knee Joint Moments (Nm/Kg), 16-year-old subjects.

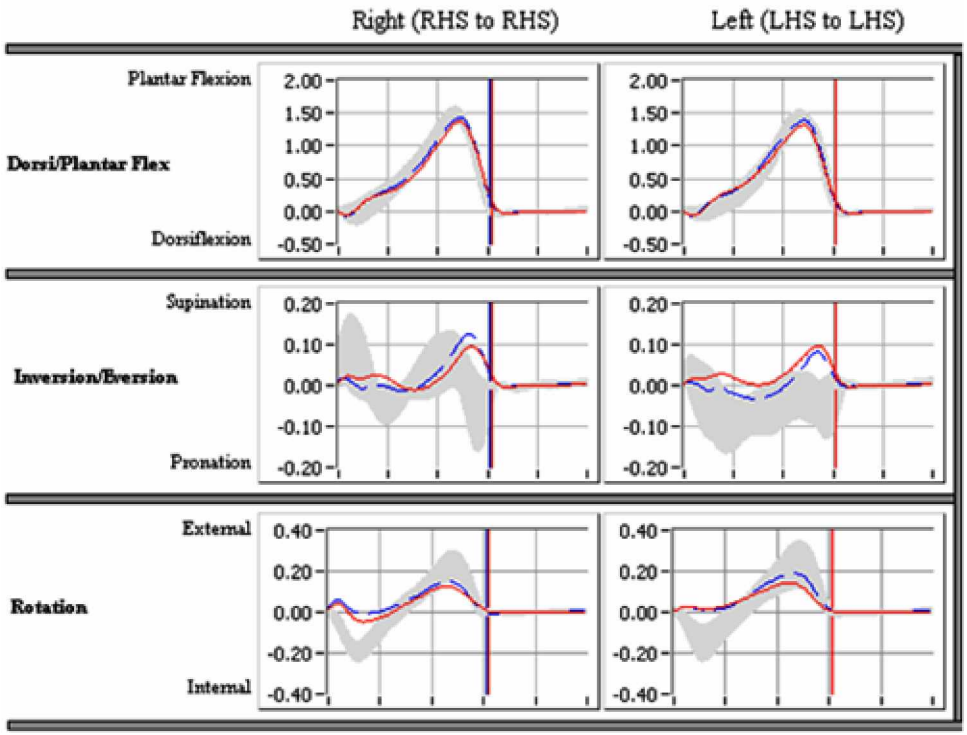

Figure C.39 Ankle Joint Moments (Nm/Kg), 16-year-old subjects.

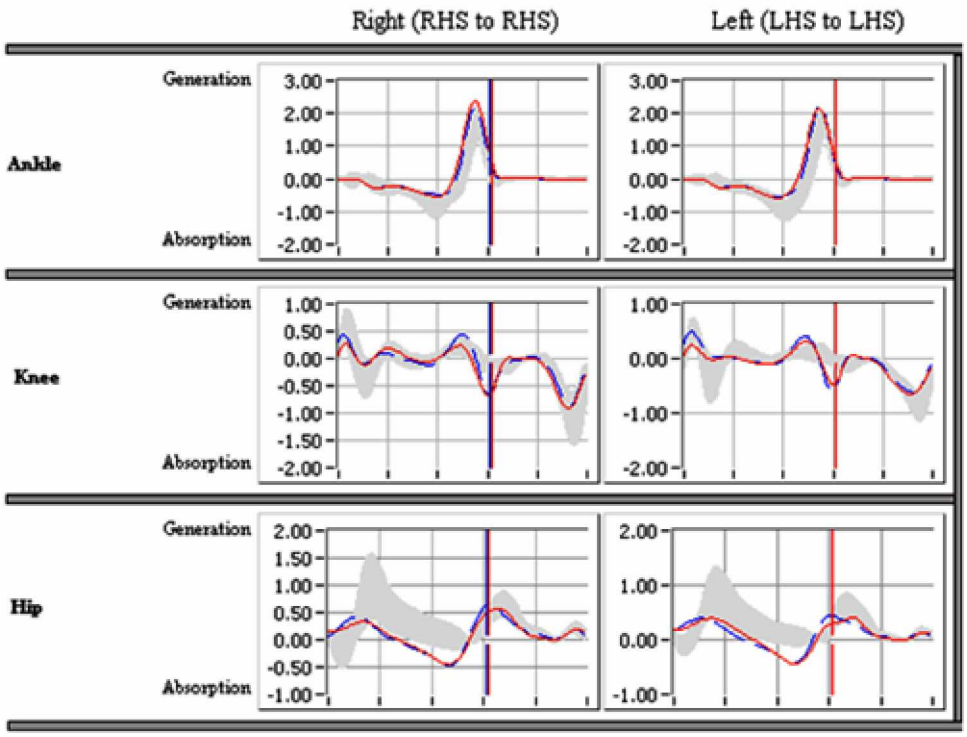

Figure C.40 Sagittal Joint Powers (Watts/Kg), 16-year-old subjects.

Table C.21 Stance Phase Kinetics of 17-year-old Female Subjects.

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	-0.06	0.02	0.91	0.07	37.30	15.42	-0.08	0.03	18.40	29.64
L_Hip_Rot_Frc	-0.06	0.03	0.92	0.07	43.50	10.07	-0.07	0.02	23.70	30.60
R_Hip_Abd_Frc	-0.03	0.02	0.23	0.05	47.10	1.45	-0.10	0.06	7.50	4.65
L_Hip_Abd_Frc	-0.04	0.03	0.24	0.04	47.40	1.43	-0.10	0.05	6.90	5.04
R_Hip_Flex_Frc	0.00	0.01	0.15	0.03	41.10	9.70	0.00	0.01	18.90	29.31
L_Hip_Flex_Frc	0.00	0.01	0.13	0.03	41.40	9.08	0.00	0.01	25.40	30.26
R_Knee_Rot_Frc	0.07	0.02	1.02	0.07	37.20	15.58	0.03	0.04	30.30	31.96
L_Knee_Rot_Frc	0.06	0.03	1.03	0.07	43.40	10.05	0.03	0.01	41.90	28.93
R_Knee_Abd_Frc	-0.07	0.02	0.31	0.03	50.10	1.10	-0.08	0.02	2.00	1.05
L_Knee_Abd_Frc	-0.08	0.02	0.29	0.04	50.20	1.14	-0.09	0.02	1.80	1.23
R_Knee_Flex_Frc	0.01	0.01	0.12	0.02	23.40	13.12	-0.01	0.01	36.60	28.73
L_Knee_Flex_Frc	0.01	0.01	0.13	0.02	23.50	13.05	-0.01	0.01	41.50	27.79
R_Ank_Rot_Frc	0.13	0.02	1.11	0.07	43.80	10.17	0.09	0.04	36.40	31.34
L_Ank_Rot_Frc	0.13	0.03	1.12	0.07	43.90	10.22	0.09	0.01	48.00	25.32
R_Ank_Abd_Frc	-0.05	0.02	0.20	0.03	54.40	1.51	-0.05	0.02	0.70	0.82
L_Ank_Abd_Frc	-0.06	0.01	0.19	0.05	55.10	1.73	-0.06	0.01	0.60	0.84
R_Ank_Flex_Frc	0.01	0.01	0.10	0.04	18.10	2.56	-0.02	0.01	46.30	22.58
L_Ank_Flex_Frc	0.00	0.01	0.11	0.03	18.40	2.22	-0.01	0.01	47.00	24.05
R_GRF_Fwd_Frc	0.00	0.00	0.18	0.04	53.30	0.82	-0.16	0.03	9.90	0.88
L_GRF_Fwd_Frc	0.00	0.00	0.20	0.05	53.30	1.16	-0.15	0.03	9.60	0.70
R_GRF_Lat_Frc	0.00	0.00	0.07	0.01	38.80	15.24	-0.03	0.01	3.80	1.03
L_GRF_Lat_Frc	0.00	0.00	0.07	0.01	21.50	14.07	-0.02	0.01	14.80	23.34
R_GRF_Vrt_Frc	0.00	0.00	1.14	0.07	44.00	10.22	0.00	0.00	0.00	0.00
L_GRF_Vrt_Frc	0.00	0.00	1.14	0.08	44.20	10.32	0.00	0.00	0.00	0.00
R_Hip_Rot_Mom	-0.02	0.01	0.10	0.08	21.30	18.32	-0.20	0.11	41.50	12.97
L_Hip_Rot_Mom	-0.01	0.01	0.09	0.10	20.00	21.16	-0.22	0.08	46.20	2.49
R_Hip_Abd_Mom	0.00	0.09	0.76	0.13	26.20	14.68	-0.04	0.05	30.70	31.55
L_Hip_Abd_Mom	-0.01	0.06	0.76	0.13	25.60	14.35	-0.03	0.05	18.80	28.69
R_Hip_Flex_Mom	0.51	0.11	0.56	0.15	2.20	3.74	-0.68	0.16	50.60	3.06
L_Hip_Flex_Mom	0.51	0.13	0.57	0.11	3.70	5.33	-0.63	0.14	50.00	1.76
R_Knee_Rot_Mom	-0.01	0.01	0.08	0.06	21.30	18.62	-0.20	0.11	41.50	12.96
L_Knee_Rot_Mom	0.00	0.01	0.07	0.08	25.90	23.54	-0.22	0.08	47.00	2.45
R_Knee_Abd_Mom	0.02	0.05	0.37	0.10	17.00	2.00	-0.07	0.04	44.10	23.19
L_Knee_Abd_Mom	0.01	0.05	0.38	0.07	17.30	2.95	-0.03	0.03	41.00	27.66
R_Knee_Flex_Mom	-0.27	0.05	0.21	0.10	49.70	19.11	-0.38	0.09	37.50	13.31
L_Knee_Flex_Mom	-0.25	0.05	0.15	0.05	54.10	14.17	-0.41	0.10	41.00	3.30
R_Ank_Rot_Mom	0.01	0.01	0.20	0.11	41.50	13.02	-0.08	0.06	21.00	18.49
L_Ank_Rot_Mom	0.00	0.01	0.22	0.07	46.70	2.67	-0.07	0.08	26.00	23.48
R_Ank_Abd_Mom	0.00	0.01	0.05	0.05	47.10	17.15	-0.04	0.02	32.40	15.53
L_Ank_Abd_Mom	0.00	0.00	0.04	0.04	53.30	4.42	-0.04	0.04	23.60	15.04
R_Ank_Flex_Mom	0.00	0.01	1.40	0.12	47.30	1.16	-0.05	0.04	3.40	0.84
L_Ank_Flex_Mom	0.00	0.01	1.35	0.13	47.50	1.43	-0.06	0.03	3.60	0.70
R_Hip_Pwr	0.31	0.22	0.73	0.22	38.10	28.78	-0.59	0.20	46.00	3.43
L_Hip_Pwr	0.43	0.28	0.66	0.22	18.20	22.70	-0.53	0.11	46.90	2.23
R_Knee_Pwr	0.05	0.15	0.43	0.16	37.00	17.13	-0.80	0.19	59.10	1.20
L_Knee_Pwr	-0.02	0.20	0.44	0.19	47.10	3.75	-0.70	0.19	59.30	1.34
R_Ank_Pwr	0.00	0.01	2.59	0.30	53.20	1.40	-0.72	0.16	39.10	2.96
L_Ank_Pwr	0.00	0.01	2.63	0.68	53.70	1.83	-0.74	0.22	37.70	3.23

Table C.22 Swing Phase Kinetics of 17-year-old Female Subjects.

	Maximum Swing		Time of Max. Sw.		Minimum Swing		Time of Min. Sw.		Toe Off	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	-0.08	0.04	65.11	8.27	-0.20	0.01	91.71	14.55	-0.09	0.05
L_Hip_Rot_Frc	-0.10	0.02	62.41	6.11	-0.20	0.01	91.71	14.55	-0.10	0.02
R_Hip_Abd_Frc	0.04	0.01	67.31	7.65	-0.01	0.01	93.81	6.60	0.03	0.01
L_Hip_Abd_Frc	0.04	0.01	68.41	10.16	-0.02	0.02	93.71	6.67	0.03	0.01
R_Hip_Flex_Frc	0.01	0.01	75.11	7.18	-0.01	0.01	89.51	9.84	0.01	0.01
L_Hip_Flex_Frc	0.01	0.01	83.41	9.53	0.00	0.01	77.71	12.69	0.01	0.00
R_Knee_Rot_Frc	0.00	0.04	65.81	7.87	-0.09	0.01	72.51	13.31	0.00	0.05
L_Knee_Rot_Frc	-0.01	0.02	62.11	5.18	-0.09	0.01	75.11	14.53	-0.01	0.02
R_Knee_Abd_Frc	0.04	0.02	60.61	1.43	-0.06	0.01	93.41	1.75	0.04	0.02
L_Knee_Abd_Frc	0.04	0.02	60.71	1.11	-0.06	0.00	93.51	1.29	0.04	0.02
R_Knee_Flex_Frc	0.01	0.01	84.11	14.47	-0.01	0.00	65.01	7.75	-0.01	0.01
L_Knee_Flex_Frc	0.02	0.01	86.51	13.83	-0.01	0.01	68.51	10.61	-0.01	0.01
R_Ank_Rot_Frc	0.05	0.04	60.61	1.43	-0.04	0.00	65.41	0.80	0.05	0.04
L_Ank_Rot_Frc	0.04	0.02	60.71	1.11	-0.04	0.00	65.31	1.17	0.04	0.02
R_Ank_Abd_Frc	0.05	0.02	60.61	1.43	-0.03	0.00	94.61	0.82	0.05	0.02
L_Ank_Abd_Frc	0.05	0.02	60.71	1.11	-0.03	0.00	94.81	1.32	0.05	0.02
R_Ank_Flex_Frc	0.01	0.00	90.91	2.95	-0.01	0.01	61.51	4.03	-0.01	0.01
L_Ank_Flex_Frc	0.01	0.00	92.21	2.92	-0.01	0.00	64.91	7.43	-0.01	0.01
R_GRF_Fwd_Frc	0.01	0.01	60.91	1.90	0.00	0.00	62.51	1.46	0.01	0.01
L_GRF_Fwd_Frc	0.01	0.01	61.01	1.66	0.00	0.00	62.81	1.63	0.01	0.01
R_GRF_Lat_Frc	0.00	0.00	61.51	2.20	0.00	0.00	61.71	1.21	0.00	0.00
L_GRF_Lat_Frc	0.00	0.00	62.51	2.03	0.00	0.00	61.01	1.08	0.00	0.00
R_GRF_Vrt_Frc	0.06	0.02	60.61	1.43	0.00	0.00	62.81	1.63	0.06	0.02
L_GRF_Vrt_Frc	0.05	0.02	60.71	1.11	0.00	0.00	63.11	1.52	0.05	0.02
R_Hip_Rot_Mom	0.02	0.01	74.61	7.31	-0.02	0.01	83.01	15.15	-0.01	0.01
L_Hip_Rot_Mom	0.02	0.01	78.01	5.87	-0.02	0.01	68.31	3.50	0.00	0.01
R_Hip_Abd_Mom	0.07	0.04	85.31	12.20	-0.04	0.02	79.21	15.20	0.01	0.05
L_Hip_Abd_Mom	0.06	0.02	80.41	11.56	-0.04	0.03	77.01	13.08	0.01	0.03
R_Hip_Flex_Mom	0.35	0.05	95.21	0.52	-0.33	0.06	60.61	1.43	-0.33	0.06
L_Hip_Flex_Mom	0.31	0.07	95.71	0.88	-0.23	0.07	60.71	1.11	-0.23	0.07
R_Knee_Rot_Mom	0.01	0.00	63.21	3.82	-0.01	0.00	79.11	14.17	0.00	0.01
L_Knee_Rot_Mom	0.01	0.00	64.91	5.09	-0.01	0.01	82.21	14.79	0.00	0.01
R_Knee_Abd_Mom	0.05	0.03	88.41	8.69	-0.04	0.03	64.51	9.35	-0.03	0.04
L_Knee_Abd_Mom	0.04	0.01	82.61	12.80	-0.03	0.01	70.01	8.65	0.00	0.02
R_Knee_Flex_Mom	0.13	0.04	60.61	1.43	-0.21	0.01	94.31	0.68	0.13	0.04
L_Knee_Flex_Mom	0.10	0.03	60.71	1.11	-0.14	0.02	94.61	0.82	0.10	0.03
R_Ank_Rot_Mom	0.01	0.00	78.31	15.43	-0.01	0.00	63.11	3.58	0.00	0.01
L_Ank_Rot_Mom	0.01	0.01	82.21	14.89	-0.01	0.00	65.31	4.75	0.00	0.01
R_Ank_Abd_Mom	0.01	0.00	73.21	16.01	0.00	0.00	62.81	2.26	0.00	0.01
L_Ank_Abd_Mom	0.01	0.00	69.31	13.60	0.00	0.00	64.71	2.89	0.01	0.01
R_Ank_Flex_Mom	0.07	0.05	60.61	1.43	-0.04	0.00	64.81	0.80	0.07	0.05
L_Ank_Flex_Mom	0.05	0.02	60.71	1.11	-0.04	0.00	64.91	1.26	0.05	0.02
R_Hip_Pwr	0.76	0.14	64.61	3.37	-0.05	0.11	85.41	3.56	0.64	0.20
L_Hip_Pwr	0.53	0.16	70.91	13.48	-0.04	0.04	86.11	4.38	0.45	0.13
R_Knee_Pwr	0.04	0.05	79.61	10.56	-0.94	0.16	87.31	10.25	-0.65	0.16
L_Knee_Pwr	0.07	0.06	67.51	2.64	-0.75	0.15	78.51	15.49	-0.55	0.18
R_Ank_Pwr	0.21	0.16	61.91	3.31	-0.01	0.01	84.41	7.42	0.20	0.16
L_Ank_Pwr	0.18	0.10	60.71	1.11	-0.03	0.02	70.21	11.40	0.18	0.10

Table C.23 Stance Phase Kinetics of 17-year-old Male Subjects.

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	-0.07	0.02	0.88	0.06	34.10	16.48	-0.07	0.02	18.50	29.80
L_Hip_Rot_Frc	-0.07	0.02	0.86	0.07	40.40	13.16	-0.09	0.03	30.50	32.16
R_Hip_Abd_Frc	-0.02	0.02	0.24	0.03	47.40	1.51	-0.12	0.05	11.70	1.06
L_Hip_Abd_Frc	-0.03	0.01	0.23	0.04	46.70	1.49	-0.11	0.07	9.90	3.98
R_Hip_Flex_Frc	0.01	0.00	0.12	0.03	38.30	11.96	0.00	0.01	54.20	18.09
L_Hip_Flex_Frc	0.01	0.01	0.10	0.03	36.00	13.75	0.00	0.01	36.50	29.14
R_Knee_Rot_Frc	0.05	0.02	0.98	0.06	40.50	13.75	0.03	0.02	30.40	32.06
L_Knee_Rot_Frc	0.05	0.03	0.97	0.07	37.00	15.22	0.02	0.05	30.50	32.16
R_Knee_Abd_Frc	-0.07	0.02	0.28	0.04	51.30	1.42	-0.08	0.02	1.90	0.99
L_Knee_Abd_Frc	-0.07	0.01	0.28	0.05	50.80	1.48	-0.08	0.01	1.70	1.06
R_Knee_Flex_Frc	0.02	0.01	0.11	0.02	24.70	14.54	-0.01	0.01	54.70	18.27
L_Knee_Flex_Frc	0.01	0.01	0.12	0.03	22.90	13.85	-0.01	0.01	42.40	27.67
R_Ank_Rot_Frc	0.11	0.03	1.07	0.08	47.20	1.03	0.09	0.03	36.50	31.43
L_Ank_Rot_Frc	0.11	0.03	1.05	0.08	46.90	1.29	0.08	0.05	30.50	32.16
R_Ank_Abd_Frc	-0.06	0.01	0.17	0.04	42.20	20.40	-0.06	0.02	0.50	0.71
L_Ank_Abd_Frc	-0.06	0.01	0.17	0.04	50.90	13.42	-0.06	0.01	0.80	0.63
R_Ank_Flex_Frc	0.01	0.00	0.08	0.02	31.40	13.43	-0.02	0.01	58.80	2.10
L_Ank_Flex_Frc	0.01	0.01	0.09	0.03	26.10	14.23	-0.02	0.02	52.80	18.66
R_GRF_Fwd_Frc	0.00	0.00	0.17	0.03	54.00	1.25	-0.16	0.02	10.40	1.07
L_GRF_Fwd_Frc	0.00	0.00	0.19	0.02	53.60	0.97	-0.14	0.03	10.30	1.25
R_GRF_Lat_Frc	0.00	0.00	0.08	0.02	48.70	2.11	-0.04	0.01	2.90	0.32
L_GRF_Lat_Frc	0.00	0.00	0.07	0.01	38.10	15.34	-0.03	0.01	8.60	18.42
R_GRF_Vrt_Frc	0.00	0.00	1.09	0.08	40.50	14.31	0.00	0.00	0.00	0.00
L_GRF_Vrt_Frc	0.00	0.00	1.07	0.09	40.60	13.56	0.00	0.00	0.00	0.00
R_Hip_Rot_Mom	-0.02	0.01	0.08	0.07	22.60	18.48	-0.21	0.05	46.70	2.67
L_Hip_Rot_Mom	-0.01	0.01	0.07	0.09	19.70	20.48	-0.22	0.08	45.40	3.10
R_Hip_Abd_Mom	0.07	0.05	0.73	0.16	30.40	15.26	-0.05	0.06	54.60	19.22
L_Hip_Abd_Mom	0.03	0.04	0.61	0.11	39.60	12.48	-0.02	0.04	30.40	31.86
R_Hip_Flex_Mom	0.49	0.11	0.50	0.11	1.10	1.45	-0.67	0.11	50.10	1.45
L_Hip_Flex_Mom	0.45	0.10	0.48	0.10	2.80	3.55	-0.62	0.16	49.40	1.71
R_Knee_Rot_Mom	-0.02	0.01	0.05	0.04	26.70	22.37	-0.21	0.06	47.20	2.57
L_Knee_Rot_Mom	-0.01	0.01	0.04	0.08	29.20	26.72	-0.22	0.07	46.00	2.87
R_Knee_Abd_Mom	0.08	0.05	0.34	0.08	28.90	14.51	-0.06	0.05	53.40	18.94
L_Knee_Abd_Mom	0.03	0.04	0.35	0.12	23.30	13.29	-0.03	0.07	40.90	28.03
R_Knee_Flex_Mom	-0.27	0.06	0.25	0.07	27.50	21.55	-0.43	0.09	38.30	13.93
L_Knee_Flex_Mom	-0.23	0.04	0.17	0.11	45.40	21.93	-0.43	0.06	41.40	2.84
R_Ank_Rot_Mom	0.02	0.01	0.20	0.06	47.10	2.85	-0.05	0.04	26.60	22.42
L_Ank_Rot_Mom	0.01	0.01	0.22	0.07	45.70	2.98	-0.04	0.08	29.00	26.46
R_Ank_Abd_Mom	0.01	0.00	0.08	0.05	47.10	16.87	-0.04	0.03	20.30	13.32
L_Ank_Abd_Mom	0.00	0.01	0.07	0.06	53.80	4.29	-0.05	0.06	23.90	11.62
R_Ank_Flex_Mom	-0.02	0.01	1.38	0.19	48.50	1.27	-0.09	0.02	3.50	0.71
L_Ank_Flex_Mom	-0.01	0.01	1.38	0.19	47.80	1.48	-0.07	0.03	3.40	0.70
R_Hip_Pwr	-0.06	0.22	0.70	0.15	60.90	1.37	-0.50	0.11	45.30	2.11
L_Hip_Pwr	0.12	0.22	0.60	0.18	29.40	26.83	-0.50	0.21	45.90	1.91
R_Knee_Pwr	0.39	0.21	0.62	0.19	29.60	24.72	-0.73	0.30	59.90	1.66
L_Knee_Pwr	0.29	0.20	0.52	0.08	34.60	22.82	-0.73	0.30	59.40	1.35
R_Ank_Pwr	-0.01	0.01	2.32	0.50	54.80	1.32	-0.65	0.27	40.90	3.93
L_Ank_Pwr	-0.01	0.01	2.49	0.72	54.50	1.35	-0.78	0.31	36.10	9.10

Table C.24 Swing Phase Kinetics of 17-year-old Male Subjects.

	Maximum Swing		Time of Max. Sw.		Minimum Swing		Time of Min. Sw.		Toe Off	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	-0.10	0.02	67.62	8.49	-0.19	0.01	84.52	16.67	-0.11	0.03
L_Hip_Rot_Frc	-0.09	0.03	69.81	8.06	-0.20	0.01	81.51	18.05	-0.11	0.05
R_Hip_Abd_Frc	0.04	0.01	66.02	5.40	0.00	0.01	89.02	9.33	0.03	0.01
L_Hip_Abd_Frc	0.03	0.01	67.41	8.21	-0.01	0.01	82.51	10.53	0.03	0.01
R_Hip_Flex_Frc	0.01	0.01	91.12	7.64	-0.01	0.01	70.42	7.42	0.00	0.01
L_Hip_Flex_Frc	0.02	0.01	94.31	7.03	-0.01	0.01	67.71	5.41	0.00	0.01
R_Knee_Rot_Frc	-0.01	0.02	66.72	7.32	-0.09	0.01	86.72	8.27	-0.02	0.02
L_Knee_Rot_Frc	0.00	0.03	67.21	7.08	-0.09	0.00	86.71	8.21	-0.02	0.04
R_Knee_Abd_Frc	0.03	0.01	61.52	1.38	-0.05	0.01	93.12	1.58	0.03	0.01
L_Knee_Abd_Frc	0.03	0.03	61.11	1.37	-0.05	0.01	92.91	1.77	0.03	0.03
R_Knee_Flex_Frc	0.02	0.01	95.12	1.77	-0.02	0.00	65.02	2.33	-0.01	0.01
L_Knee_Flex_Frc	0.02	0.01	96.21	1.77	-0.02	0.00	65.81	1.48	-0.01	0.01
R_Ank_Rot_Frc	0.04	0.02	61.52	1.38	-0.04	0.00	68.12	6.59	0.04	0.02
L_Ank_Rot_Frc	0.04	0.04	62.21	4.20	-0.04	0.00	67.51	7.15	0.04	0.04
R_Ank_Abd_Frc	0.04	0.01	61.52	1.38	-0.03	0.00	94.82	0.78	0.04	0.01
L_Ank_Abd_Frc	0.04	0.03	61.11	1.37	-0.03	0.01	94.21	0.84	0.04	0.03
R_Ank_Flex_Frc	0.01	0.00	94.92	1.41	-0.01	0.00	63.42	4.52	-0.01	0.01
L_Ank_Flex_Frc	0.01	0.00	94.21	1.77	-0.01	0.01	64.61	4.21	-0.01	0.01
R_GRF_Fwd_Frc	0.02	0.01	62.22	2.18	0.00	0.00	63.82	1.56	0.01	0.01
L_GRF_Fwd_Frc	0.01	0.01	62.41	2.00	0.00	0.00	63.21	1.65	0.01	0.01
R_GRF_Lat_Frc	0.00	0.00	62.52	1.86	0.00	0.00	63.12	1.72	0.00	0.00
L_GRF_Lat_Frc	0.00	0.00	62.71	1.74	0.00	0.00	62.71	1.60	0.00	0.00
R_GRF_Vrt_Frc	0.05	0.02	61.52	1.38	0.00	0.00	64.32	1.43	0.05	0.02
L_GRF_Vrt_Frc	0.06	0.03	61.31	1.26	0.00	0.00	64.41	1.24	0.06	0.03
R_Hip_Rot_Mom	0.01	0.00	80.12	3.60	-0.02	0.01	70.42	14.22	-0.02	0.01
L_Hip_Rot_Mom	0.01	0.00	80.41	7.91	-0.04	0.02	66.71	4.10	-0.01	0.02
R_Hip_Abd_Mom	0.11	0.02	97.62	1.55	-0.07	0.04	64.62	3.71	-0.06	0.05
L_Hip_Abd_Mom	0.09	0.03	95.11	5.71	-0.05	0.04	67.91	4.72	-0.02	0.05
R_Hip_Flex_Mom	0.35	0.07	95.02	0.70	-0.29	0.05	61.52	1.38	-0.29	0.05
L_Hip_Flex_Mom	0.28	0.05	94.91	0.94	-0.21	0.07	61.11	1.37	-0.21	0.07
R_Knee_Rot_Mom	0.01	0.00	64.02	3.00	-0.01	0.01	90.42	10.21	0.00	0.01
L_Knee_Rot_Mom	0.01	0.00	65.51	4.75	-0.01	0.01	84.01	14.99	0.00	0.01
R_Knee_Abd_Mom	0.09	0.03	96.12	1.17	-0.04	0.02	62.42	1.62	-0.04	0.03
L_Knee_Abd_Mom	0.05	0.02	95.11	3.89	-0.04	0.01	67.21	4.59	-0.01	0.02
R_Knee_Flex_Mom	0.11	0.03	61.52	1.38	-0.20	0.03	94.82	0.63	0.11	0.03
L_Knee_Flex_Mom	0.10	0.05	61.11	1.37	-0.13	0.02	94.51	0.73	0.10	0.05
R_Ank_Rot_Mom	0.01	0.01	86.62	13.24	-0.01	0.00	64.12	3.11	0.00	0.01
L_Ank_Rot_Mom	0.01	0.01	81.11	16.53	-0.01	0.00	65.41	4.42	0.00	0.01
R_Ank_Abd_Mom	0.01	0.00	74.82	16.87	0.00	0.00	64.32	1.96	0.01	0.01
L_Ank_Abd_Mom	0.01	0.01	73.61	16.09	0.00	0.00	64.91	2.80	0.01	0.01
R_Ank_Flex_Mom	0.06	0.03	61.52	1.38	-0.04	0.01	65.72	1.11	0.06	0.03
L_Ank_Flex_Mom	0.06	0.05	64.41	11.04	-0.03	0.01	65.01	1.27	0.06	0.06
R_Hip_Pwr	0.71	0.14	62.52	2.24	-0.05	0.08	93.12	7.11	0.71	0.15
L_Hip_Pwr	0.53	0.23	61.91	2.41	-0.03	0.07	88.61	5.48	0.51	0.24
R_Knee_Pwr	0.11	0.10	81.32	12.46	-0.92	0.19	88.32	10.13	-0.59	0.23
L_Knee_Pwr	0.09	0.08	77.91	14.67	-0.67	0.25	83.61	12.21	-0.55	0.27
R_Ank_Pwr	0.16	0.06	61.52	1.38	-0.02	0.02	79.32	10.42	0.16	0.06
L_Ank_Pwr	0.19	0.16	61.71	2.74	-0.02	0.01	68.11	9.28	0.19	0.17

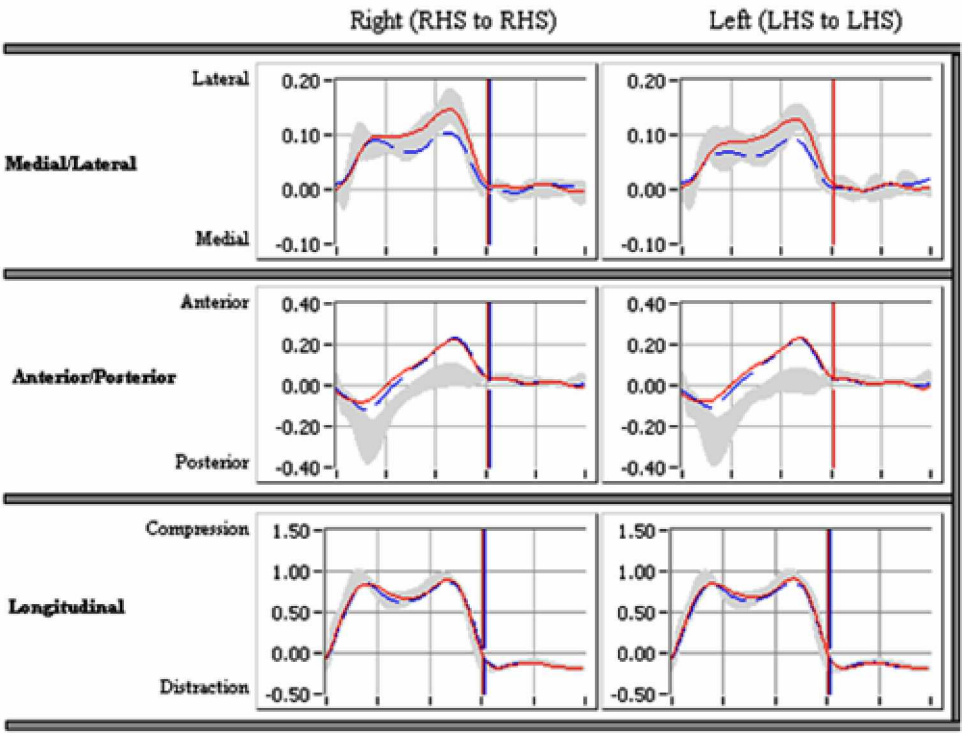

Figure C.41 Hip Joint Forces (N), 17-year-old subjects.

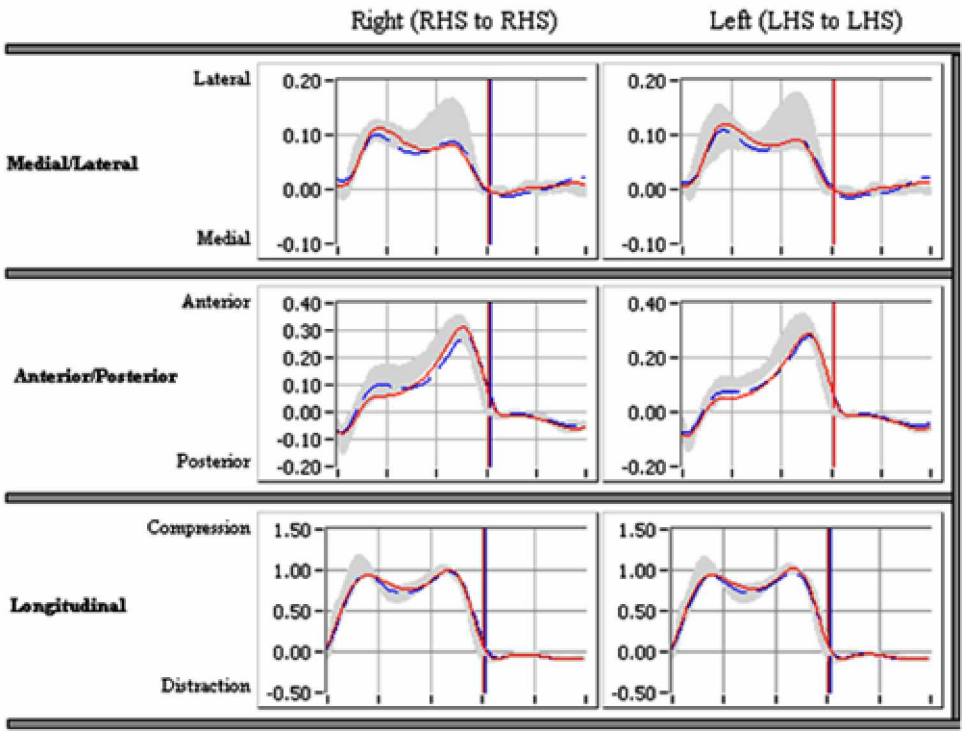

Figure C.42 Knee Joint Forces (N), 17-year-old subjects.

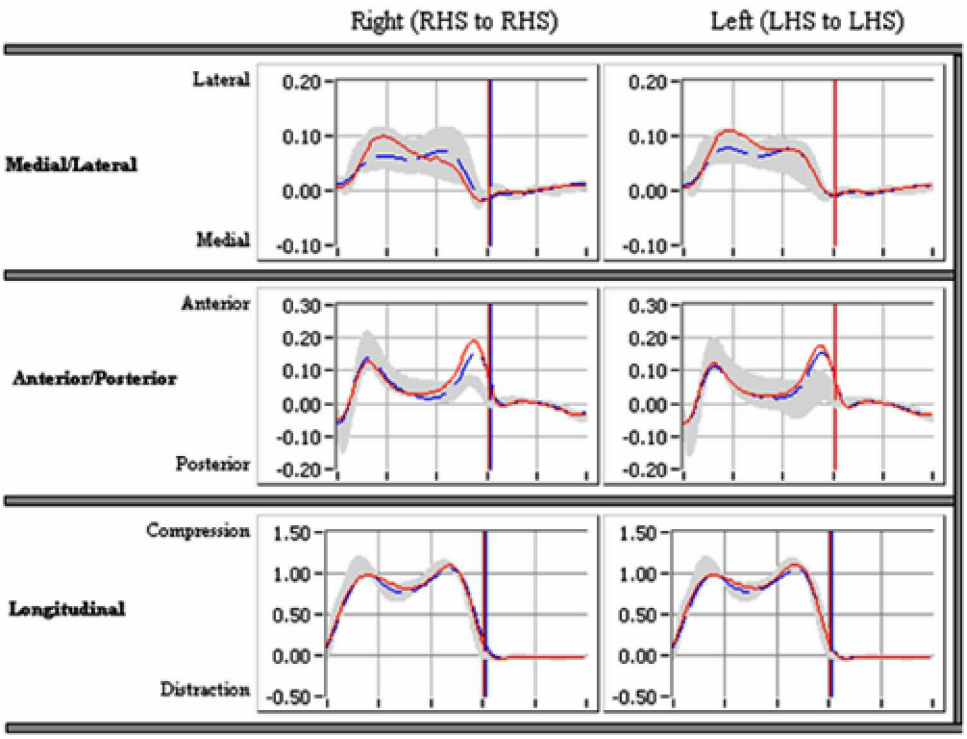

Figure C.43 Ankle Joint Forces (N), 17-year-old subjects.

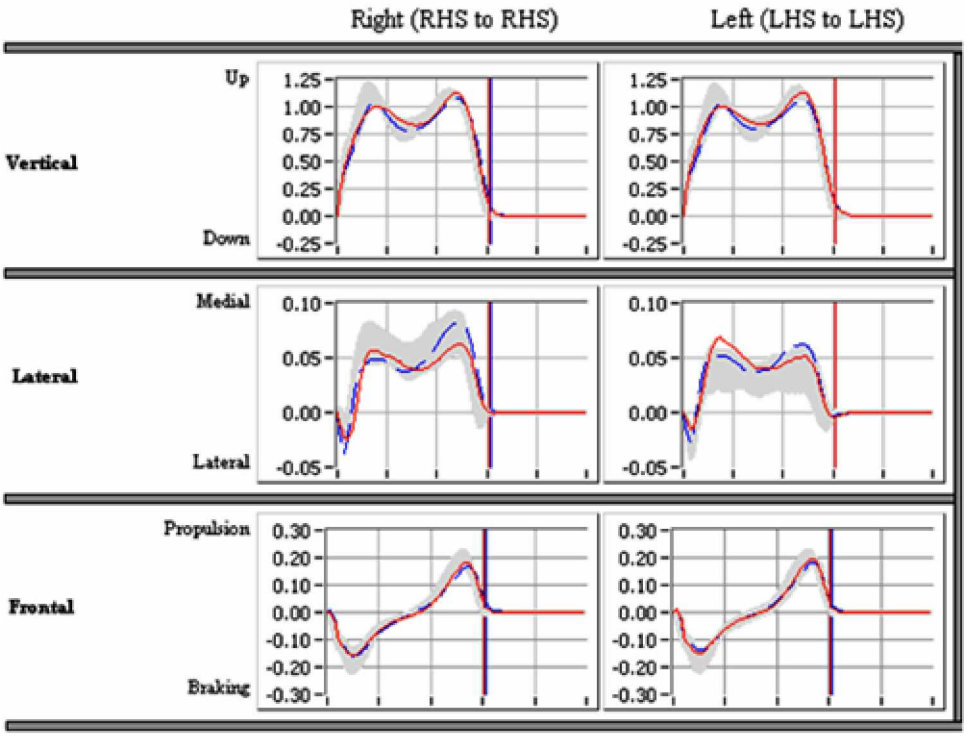

Figure C.44 Ground Reaction Forces (N), 17-year-old subjects.

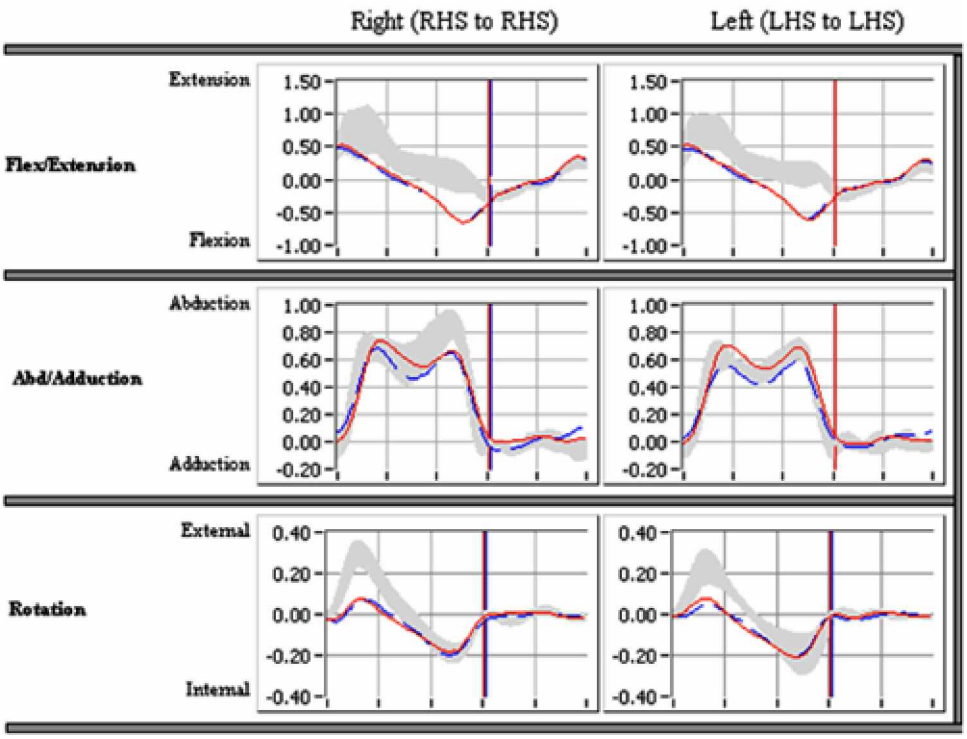

Figure C.45 Hip Joint Moments (Nm/Kg), 17-year-old subjects.

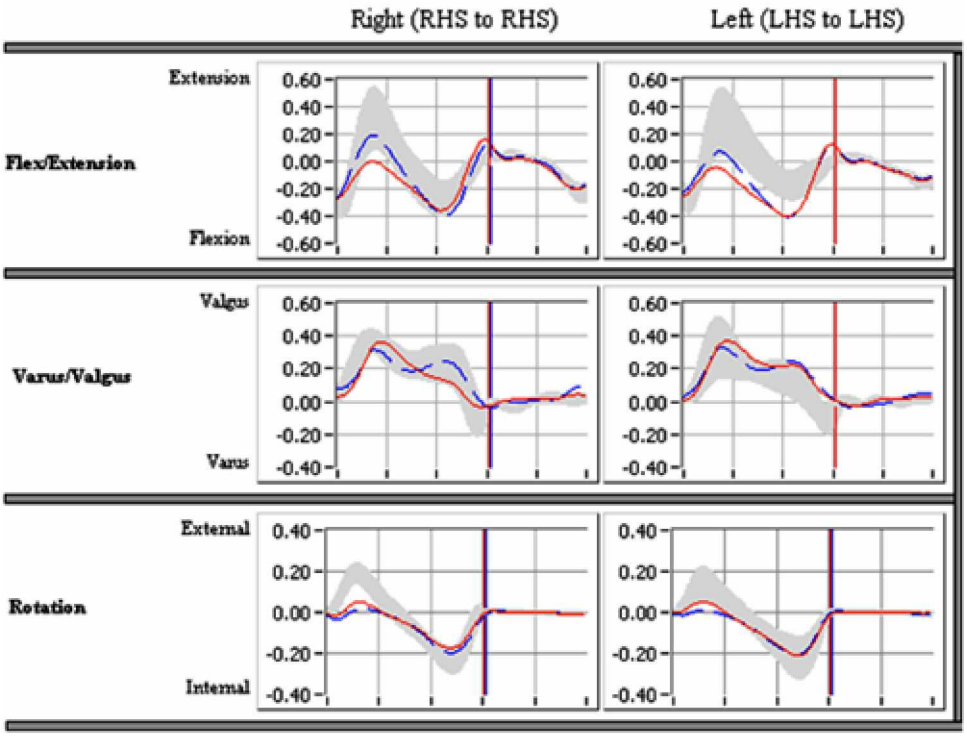

Figure C.46 Knee Joint Moments (Nm/Kg), 17-year-old subjects.

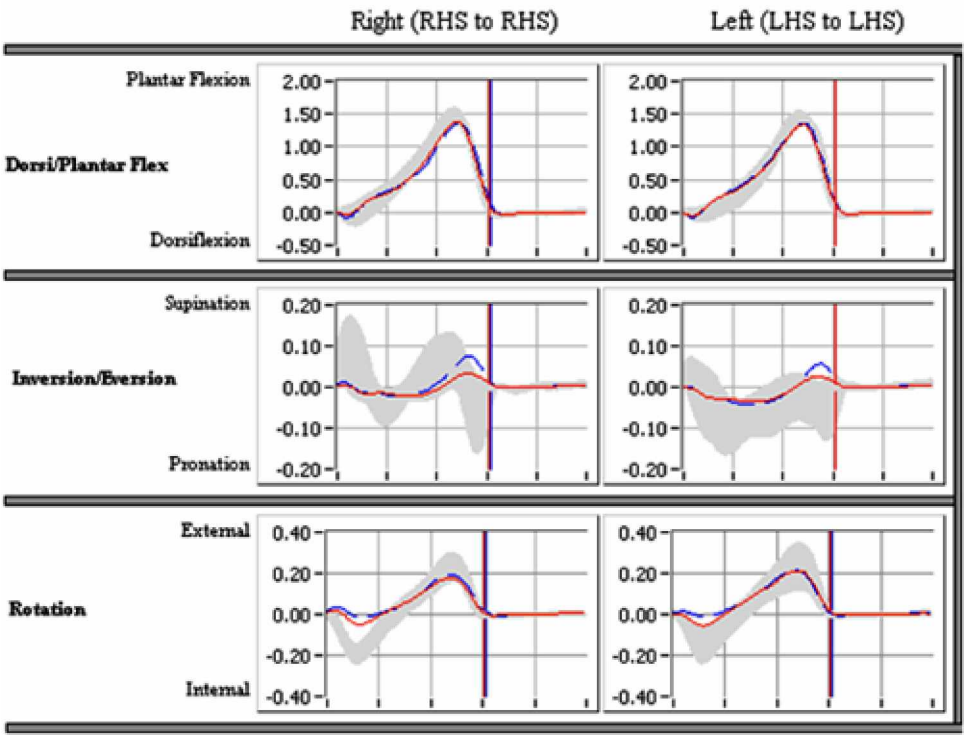

Figure C.47 Ankle Joint Moments (Nm/Kg), 17-year-old subjects.

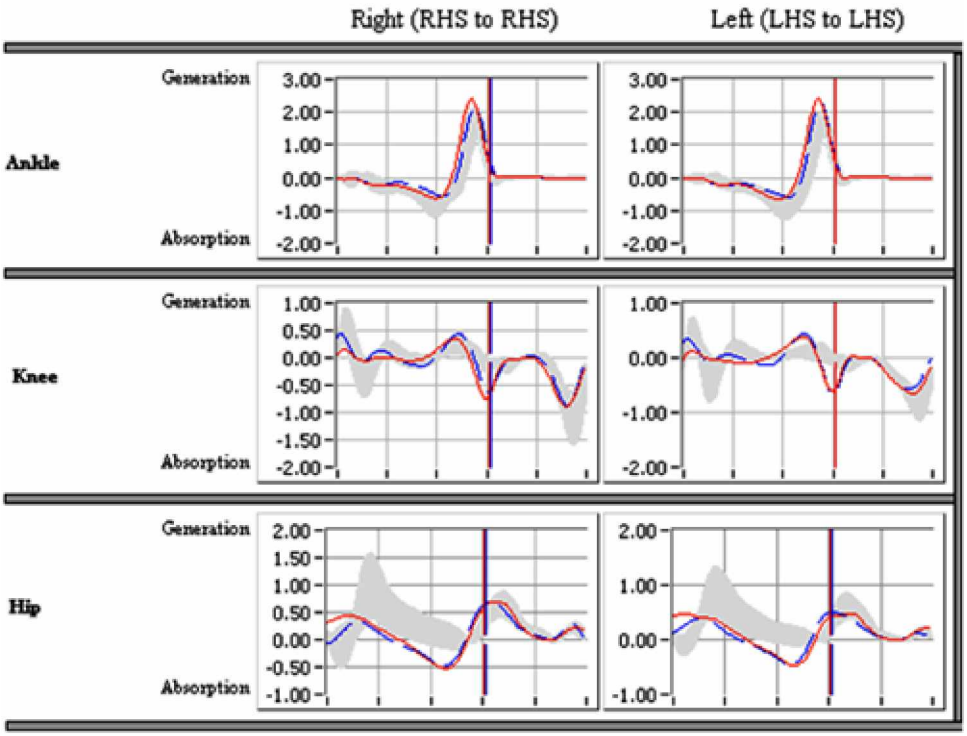

Figure C.48 Sagittal Joint Powers (Watts/Kg), 17-year-old subjects.

Table C.25 Stance Phase Kinetics of 18-year-old Female Subjects.

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	-0.06	0.03	0.91	0.06	37.50	15.11	-0.06	0.03	6.00	18.97
L_Hip_Rot_Frc	-0.06	0.03	0.91	0.06	43.40	9.67	-0.07	0.02	17.90	28.82
R_Hip_Abd_Frc	-0.03	0.02	0.22	0.06	47.40	1.17	-0.10	0.05	7.90	3.90
L_Hip_Abd_Frc	-0.03	0.02	0.22	0.04	47.20	1.40	-0.10	0.04	8.40	4.30
R_Hip_Flex_Frc	0.00	0.01	0.15	0.04	42.50	6.74	0.00	0.01	6.50	18.49
L_Hip_Flex_Frc	0.00	0.01	0.14	0.03	42.00	8.60	0.00	0.01	18.30	28.57
R_Knee_Rot_Frc	0.06	0.03	1.01	0.07	37.50	15.11	0.05	0.03	36.20	31.16
L_Knee_Rot_Frc	0.06	0.03	1.02	0.06	43.40	9.69	0.04	0.02	35.70	30.73
R_Knee_Abd_Frc	-0.07	0.02	0.31	0.02	49.90	0.88	-0.08	0.02	1.50	1.18
L_Knee_Abd_Frc	-0.07	0.02	0.31	0.04	49.60	0.97	-0.08	0.02	1.40	1.07
R_Knee_Flex_Frc	0.01	0.02	0.14	0.03	20.20	8.83	-0.02	0.02	40.60	27.37
L_Knee_Flex_Frc	0.01	0.01	0.13	0.02	17.60	2.07	-0.01	0.01	46.50	23.78
R_Ank_Rot_Frc	0.13	0.03	1.10	0.07	46.90	0.57	0.11	0.03	42.30	29.20
L_Ank_Rot_Frc	0.13	0.03	1.11	0.07	46.80	1.23	0.10	0.02	35.70	30.73
R_Ank_Abd_Frc	-0.05	0.02	0.20	0.02	54.60	0.97	-0.06	0.02	0.80	0.79
L_Ank_Abd_Frc	-0.05	0.01	0.20	0.03	54.50	1.27	-0.06	0.01	0.40	0.70
R_Ank_Flex_Frc	0.01	0.01	0.12	0.03	18.50	1.90	-0.02	0.01	52.60	17.49
L_Ank_Flex_Frc	0.01	0.01	0.12	0.02	18.80	2.39	-0.01	0.01	46.80	23.37
R_GRF_Fwd_Frc	0.00	0.00	0.19	0.04	53.20	0.42	-0.16	0.02	10.10	0.88
L_GRF_Fwd_Frc	0.00	0.00	0.20	0.04	53.00	1.05	-0.15	0.03	9.80	1.32
R_GRF_Lat_Frc	0.00	0.00	0.07	0.02	34.90	15.63	-0.03	0.01	3.40	0.97
L_GRF_Lat_Frc	0.00	0.00	0.07	0.02	32.00	15.90	-0.02	0.00	3.40	1.07
R_GRF_Vrt_Frc	0.00	0.00	1.13	0.07	47.10	0.57	0.00	0.00	0.00	0.00
L_GRF_Vrt_Frc	0.00	0.00	1.13	0.07	44.10	9.57	0.00	0.00	0.00	0.00
R_Hip_Rot_Mom	-0.02	0.01	0.08	0.07	25.00	21.42	-0.20	0.11	43.90	5.00
L_Hip_Rot_Mom	-0.01	0.01	0.07	0.09	24.20	24.05	-0.21	0.08	45.50	3.06
R_Hip_Abd_Mom	0.00	0.06	0.82	0.13	26.10	13.80	-0.01	0.06	24.10	30.70
L_Hip_Abd_Mom	0.00	0.05	0.78	0.13	28.60	15.44	-0.01	0.05	23.90	30.43
R_Hip_Flex_Mom	0.48	0.11	0.53	0.13	3.40	5.19	-0.59	0.20	51.90	3.07
L_Hip_Flex_Mom	0.43	0.12	0.48	0.11	4.10	5.13	-0.59	0.16	49.70	1.57
R_Knee_Rot_Mom	-0.01	0.01	0.06	0.06	30.10	24.28	-0.20	0.11	44.10	5.07
L_Knee_Rot_Mom	0.00	0.01	0.05	0.08	34.20	26.50	-0.21	0.08	45.90	3.11
R_Knee_Abd_Mom	0.03	0.06	0.44	0.08	17.30	1.77	-0.06	0.04	41.10	27.93
L_Knee_Abd_Mom	0.03	0.04	0.41	0.08	17.50	2.92	-0.02	0.03	47.20	23.86
R_Knee_Flex_Mom	-0.25	0.05	0.16	0.07	49.70	19.62	-0.38	0.08	37.30	13.35
L_Knee_Flex_Mom	-0.21	0.05	0.14	0.04	49.00	19.32	-0.36	0.10	40.00	3.77
R_Ank_Rot_Mom	0.01	0.01	0.20	0.11	44.00	5.08	-0.06	0.06	29.80	24.11
L_Ank_Rot_Mom	0.00	0.01	0.21	0.08	45.50	3.17	-0.05	0.08	34.80	25.55
R_Ank_Abd_Mom	0.00	0.01	0.07	0.04	51.00	4.03	-0.03	0.02	28.30	14.35
L_Ank_Abd_Mom	0.00	0.01	0.06	0.04	52.30	3.23	-0.04	0.04	19.60	9.56
R_Ank_Flex_Mom	0.00	0.01	1.33	0.08	47.30	0.95	-0.04	0.02	3.20	0.63
L_Ank_Flex_Mom	-0.01	0.01	1.31	0.14	47.10	1.37	-0.06	0.03	3.50	0.53
R_Hip_Pwr	0.32	0.18	0.73	0.22	35.40	26.48	-0.59	0.25	47.60	3.69
L_Hip_Pwr	0.30	0.24	0.60	0.20	29.00	26.12	-0.59	0.23	47.10	1.97
R_Knee_Pwr	0.14	0.12	0.42	0.10	44.80	10.38	-0.71	0.27	59.40	1.17
L_Knee_Pwr	0.04	0.19	0.37	0.14	46.60	3.66	-0.68	0.25	56.20	8.22
R_Ank_Pwr	-0.01	0.01	2.56	0.35	53.20	0.63	-0.66	0.17	36.40	5.48
L_Ank_Pwr	-0.01	0.01	2.59	0.64	53.40	1.17	-0.68	0.26	35.60	7.86

Table C.26 Swing Phase Kinetics of 18-year-old Female Subjects.

	Maximum Swing		Time of Max. Sw.		Minimum Swing		Time of Min. Sw.		Toe Off	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	-0.08	0.03	60.61	1.06	-0.20	0.01	85.11	17.44	-0.08	0.03
L_Hip_Rot_Frc	-0.08	0.03	61.80	5.27	-0.20	0.01	81.50	18.04	-0.09	0.03
R_Hip_Abd_Frc	0.04	0.01	67.91	7.66	-0.01	0.01	90.81	8.15	0.03	0.01
L_Hip_Abd_Frc	0.03	0.01	67.50	8.80	-0.01	0.01	92.90	6.31	0.03	0.01
R_Hip_Flex_Frc	0.01	0.01	72.51	8.62	-0.01	0.01	87.51	10.67	0.00	0.01
L_Hip_Flex_Frc	0.01	0.01	75.50	10.05	-0.01	0.01	82.50	12.57	0.00	0.00
R_Knee_Rot_Frc	0.00	0.03	63.41	6.74	-0.09	0.01	75.11	13.70	0.00	0.03
L_Knee_Rot_Frc	0.00	0.03	61.60	4.65	-0.09	0.00	72.40	13.59	0.00	0.03
R_Knee_Abd_Frc	0.05	0.02	60.61	1.06	-0.06	0.01	93.31	1.25	0.05	0.02
L_Knee_Abd_Frc	0.04	0.01	60.20	0.85	-0.06	0.01	92.90	1.16	0.04	0.01
R_Knee_Flex_Frc	0.02	0.01	84.31	13.75	-0.01	0.00	63.31	2.99	-0.01	0.01
L_Knee_Flex_Frc	0.02	0.00	92.30	3.98	-0.01	0.00	64.20	4.58	-0.01	0.01
R_Ank_Rot_Frc	0.06	0.03	60.61	1.06	-0.04	0.00	65.71	0.58	0.06	0.03
L_Ank_Rot_Frc	0.06	0.03	60.20	0.85	-0.04	0.00	65.10	0.98	0.06	0.03
R_Ank_Abd_Frc	0.05	0.02	60.61	1.06	-0.03	0.00	94.01	0.70	0.05	0.02
L_Ank_Abd_Frc	0.05	0.01	60.20	0.85	-0.03	0.01	94.10	1.08	0.05	0.01
R_Ank_Flex_Frc	0.01	0.00	91.71	2.13	-0.01	0.01	60.61	1.06	-0.01	0.01
L_Ank_Flex_Frc	0.01	0.00	92.20	2.22	-0.01	0.00	62.10	6.21	-0.01	0.00
R_GRF_Fwd_Frc	0.02	0.01	60.61	1.06	0.00	0.00	62.81	1.41	0.02	0.01
L_GRF_Fwd_Frc	0.02	0.01	60.20	0.85	0.00	0.00	62.60	1.06	0.02	0.01
R_GRF_Lat_Frc	0.00	0.00	61.81	1.88	0.00	0.00	61.61	1.57	0.00	0.00
L_GRF_Lat_Frc	0.00	0.00	62.00	1.44	0.00	0.00	60.50	1.00	0.00	0.00
R_GRF_Vrt_Frc	0.06	0.02	60.61	1.06	0.00	0.00	62.91	1.43	0.06	0.02
L_GRF_Vrt_Frc	0.06	0.02	60.20	0.85	0.00	0.00	62.60	1.06	0.06	0.02
R_Hip_Rot_Mom	0.02	0.01	70.71	6.81	-0.02	0.01	82.01	14.04	0.00	0.01
L_Hip_Rot_Mom	0.02	0.01	76.80	6.43	-0.02	0.01	69.10	5.92	0.00	0.01
R_Hip_Abd_Mom	0.06	0.03	79.21	14.55	-0.04	0.02	77.01	14.70	0.02	0.04
L_Hip_Abd_Mom	0.05	0.02	77.00	12.43	-0.04	0.03	74.50	13.52	0.01	0.03
R_Hip_Flex_Mom	0.34	0.06	94.81	0.63	-0.31	0.07	60.61	1.06	-0.31	0.07
L_Hip_Flex_Mom	0.26	0.07	95.10	0.97	-0.21	0.05	61.00	2.80	-0.21	0.05
R_Knee_Rot_Mom	0.01	0.00	62.11	1.96	-0.01	0.00	82.21	13.11	0.00	0.01
L_Knee_Rot_Mom	0.01	0.00	62.90	3.49	-0.01	0.01	78.20	15.66	0.00	0.01
R_Knee_Abd_Mom	0.06	0.03	88.11	12.25	-0.04	0.02	67.31	13.05	-0.03	0.04
L_Knee_Abd_Mom	0.04	0.01	90.00	5.93	-0.03	0.01	66.80	4.92	-0.01	0.02
R_Knee_Flex_Mom	0.12	0.04	60.61	1.06	-0.20	0.03	93.91	0.82	0.12	0.04
L_Knee_Flex_Mom	0.10	0.02	60.20	0.85	-0.13	0.02	94.20	0.84	0.10	0.02
R_Ank_Rot_Mom	0.01	0.00	78.71	15.64	-0.01	0.00	62.31	1.95	0.00	0.01
L_Ank_Rot_Mom	0.01	0.01	77.80	15.26	-0.01	0.00	62.70	2.69	0.00	0.01
R_Ank_Abd_Mom	0.01	0.01	73.01	16.74	0.00	0.00	63.81	1.75	0.01	0.01
L_Ank_Abd_Mom	0.01	0.01	66.40	13.33	0.00	0.00	63.70	1.92	0.01	0.01
R_Ank_Flex_Mom	0.07	0.04	60.61	1.06	-0.04	0.00	65.01	0.85	0.07	0.04
L_Ank_Flex_Mom	0.07	0.03	60.20	0.85	-0.03	0.00	64.70	1.00	0.07	0.03
R_Hip_Pwr	0.74	0.18	65.31	3.13	-0.05	0.11	85.91	3.65	0.60	0.25
L_Hip_Pwr	0.54	0.13	68.40	10.21	-0.01	0.02	84.80	4.05	0.42	0.15
R_Knee_Pwr	0.05	0.05	80.01	13.57	-0.93	0.15	87.01	10.09	-0.63	0.22
L_Knee_Pwr	0.10	0.07	69.60	10.39	-0.69	0.13	80.70	13.98	-0.53	0.17
R_Ank_Pwr	0.20	0.12	61.11	2.42	-0.01	0.01	85.31	8.60	0.19	0.12
L_Ank_Pwr	0.21	0.10	60.20	0.85	-0.02	0.02	74.30	11.97	0.21	0.10

Table C.27 Stance Phase Kinetics of 18-year-old Male Subjects.

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	-0.05	0.04	0.87	0.04	40.45	13.40	-0.08	0.03	28.09	32.28
L_Hip_Rot_Frc	-0.04	0.04	0.88	0.04	35.09	16.78	-0.07	0.02	27.82	31.97
R_Hip_Abd_Frc	-0.03	0.02	0.23	0.03	47.55	1.21	-0.11	0.04	9.09	4.21
L_Hip_Abd_Frc	-0.04	0.02	0.22	0.04	47.36	1.12	-0.11	0.05	8.55	4.70
R_Hip_Flex_Frc	0.01	0.01	0.10	0.04	40.73	10.25	-0.01	0.01	38.09	29.48
L_Hip_Flex_Frc	0.01	0.01	0.07	0.03	34.27	11.89	-0.01	0.01	53.36	17.10
R_Knee_Rot_Frc	0.07	0.04	0.98	0.04	37.45	15.54	0.02	0.03	50.09	24.79
L_Knee_Rot_Frc	0.07	0.04	0.98	0.05	37.18	15.85	0.04	0.03	38.91	30.85
R_Knee_Abd_Frc	-0.08	0.01	0.29	0.04	51.27	1.19	-0.09	0.02	2.18	0.75
L_Knee_Abd_Frc	-0.09	0.02	0.29	0.04	51.27	1.10	-0.10	0.02	2.27	0.79
R_Knee_Flex_Frc	0.02	0.02	0.12	0.02	26.09	15.62	-0.01	0.01	55.45	17.50
L_Knee_Flex_Frc	0.02	0.02	0.13	0.03	25.45	15.47	0.00	0.01	39.64	29.85
R_Ank_Rot_Frc	0.13	0.04	1.06	0.05	40.64	13.71	0.08	0.04	50.09	24.79
L_Ank_Rot_Frc	0.13	0.04	1.06	0.06	43.64	11.26	0.10	0.03	33.36	31.95
R_Ank_Abd_Frc	-0.06	0.01	0.17	0.03	51.55	13.16	-0.07	0.01	0.91	0.54
L_Ank_Abd_Frc	-0.07	0.01	0.16	0.04	56.18	1.33	-0.07	0.01	1.27	0.47
R_Ank_Flex_Frc	0.01	0.01	0.10	0.02	25.18	13.68	-0.02	0.01	59.64	1.96
L_Ank_Flex_Frc	0.01	0.01	0.11	0.03	27.82	14.41	-0.01	0.01	54.45	18.13
R_GRF_Fwd_Frc	0.00	0.00	0.16	0.03	54.36	1.12	-0.17	0.03	8.64	2.11
L_GRF_Fwd_Frc	0.00	0.00	0.17	0.03	54.36	0.81	-0.16	0.03	8.45	2.34
R_GRF_Lat_Frc	0.00	0.00	0.08	0.03	40.82	13.80	-0.04	0.01	3.27	1.62
L_GRF_Lat_Frc	0.00	0.00	0.07	0.02	27.00	16.10	-0.03	0.01	8.09	17.55
R_GRF_Vrt_Frc	0.00	0.00	1.08	0.06	40.64	13.97	0.00	0.00	0.00	0.00
L_GRF_Vrt_Frc	0.00	0.00	1.08	0.06	37.64	16.49	0.00	0.00	0.00	0.00
R_Hip_Rot_Mom	-0.02	0.01	0.09	0.07	15.45	14.98	-0.19	0.04	46.73	2.87
L_Hip_Rot_Mom	0.00	0.01	0.09	0.08	19.64	19.45	-0.19	0.07	46.82	4.42
R_Hip_Abd_Mom	0.03	0.07	0.70	0.12	34.36	15.11	-0.06	0.05	44.45	28.58
L_Hip_Abd_Mom	0.05	0.05	0.59	0.10	26.55	14.77	-0.05	0.04	50.00	24.74
R_Hip_Flex_Mom	0.57	0.11	0.60	0.11	2.45	2.54	-0.63	0.15	51.09	3.24
L_Hip_Flex_Mom	0.57	0.13	0.60	0.11	2.45	1.51	-0.65	0.16	49.73	1.35
R_Knee_Rot_Mom	-0.02	0.01	0.06	0.05	25.00	22.78	-0.20	0.05	47.45	2.58
L_Knee_Rot_Mom	-0.01	0.01	0.07	0.08	34.00	25.88	-0.22	0.06	47.27	4.47
R_Knee_Abd_Mom	0.09	0.09	0.39	0.07	25.91	13.90	-0.03	0.03	55.36	18.38
L_Knee_Abd_Mom	0.05	0.07	0.38	0.12	20.18	11.34	-0.02	0.04	43.91	27.92
R_Knee_Flex_Mom	-0.30	0.05	0.20	0.09	42.64	23.74	-0.42	0.08	38.91	12.96
L_Knee_Flex_Mom	-0.28	0.07	0.18	0.11	38.91	23.88	-0.39	0.07	27.36	20.74
R_Ank_Rot_Mom	0.02	0.01	0.19	0.05	46.73	3.20	-0.06	0.05	24.91	22.82
L_Ank_Rot_Mom	0.01	0.01	0.22	0.05	46.91	4.28	-0.07	0.08	33.82	25.69
R_Ank_Abd_Mom	0.01	0.01	0.11	0.07	52.73	2.69	-0.03	0.03	19.27	10.95
L_Ank_Abd_Mom	0.00	0.01	0.07	0.04	54.36	2.91	-0.08	0.03	20.91	10.37
R_Ank_Flex_Mom	-0.01	0.01	1.37	0.15	48.27	1.35	-0.07	0.02	3.73	0.65
L_Ank_Flex_Mom	-0.02	0.01	1.36	0.15	48.64	1.12	-0.09	0.04	3.91	0.83
R_Hip_Pwr	0.17	0.28	0.67	0.17	51.18	21.52	-0.50	0.13	46.18	1.83
L_Hip_Pwr	0.21	0.26	0.63	0.20	50.55	21.10	-0.54	0.21	45.36	1.96
R_Knee_Pwr	0.21	0.27	0.59	0.13	36.64	22.34	-0.76	0.29	60.09	1.70
L_Knee_Pwr	0.13	0.29	0.54	0.10	31.91	22.80	-0.79	0.29	60.00	1.26
R_Ank_Pwr	-0.01	0.01	2.26	0.60	54.55	1.21	-0.70	0.27	40.27	3.32
L_Ank_Pwr	-0.02	0.01	2.32	0.79	55.18	1.25	-0.81	0.23	40.27	4.17

Table C.28 Swing Phase Kinetics of 18-year-old Male Subjects.

	Maximum Swing		Time of Max. Sw.		Minimum Swing		Time of Min. Sw.		Toe Off	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	-0.10	0.02	65.62	6.34	-0.19	0.01	94.07	10.29	-0.11	0.03
L_Hip_Rot_Frc	-0.09	0.03	66.80	7.25	-0.19	0.01	94.62	10.39	-0.10	0.04
R_Hip_Abd_Frc	0.03	0.01	64.53	2.08	-0.01	0.01	93.44	5.97	0.03	0.01
L_Hip_Abd_Frc	0.04	0.01	67.89	7.66	-0.01	0.01	89.53	10.36	0.03	0.01
R_Hip_Flex_Frc	0.02	0.01	90.35	7.59	0.00	0.01	66.62	8.60	0.00	0.01
L_Hip_Flex_Frc	0.02	0.01	93.98	6.27	0.00	0.01	65.98	4.46	0.00	0.01
R_Knee_Rot_Frc	-0.01	0.02	64.07	5.13	-0.09	0.00	90.26	2.01	-0.02	0.02
L_Knee_Rot_Frc	0.00	0.03	66.34	6.62	-0.09	0.00	90.62	1.85	0.00	0.03
R_Knee_Abd_Frc	0.03	0.02	61.89	1.28	-0.05	0.01	93.53	1.22	0.03	0.02
L_Knee_Abd_Frc	0.04	0.02	61.71	0.95	-0.06	0.01	93.53	1.22	0.04	0.02
R_Knee_Flex_Frc	0.02	0.01	96.07	1.81	-0.02	0.00	64.44	2.05	-0.01	0.01
L_Knee_Flex_Frc	0.02	0.01	96.62	1.90	-0.02	0.00	67.16	5.65	0.00	0.01
R_Ank_Rot_Frc	0.04	0.02	61.89	1.28	-0.04	0.00	66.35	1.11	0.04	0.02
L_Ank_Rot_Frc	0.06	0.03	61.71	0.95	-0.04	0.00	68.44	6.42	0.06	0.03
R_Ank_Abd_Frc	0.04	0.02	61.89	1.28	-0.03	0.00	95.07	0.82	0.04	0.02
L_Ank_Abd_Frc	0.05	0.02	61.71	0.95	-0.03	0.00	95.44	0.61	0.05	0.02
R_Ank_Flex_Frc	0.01	0.00	93.53	3.59	-0.01	0.00	63.07	3.14	-0.01	0.00
L_Ank_Flex_Frc	0.01	0.00	91.89	10.12	-0.01	0.00	63.25	4.01	-0.01	0.01
R_GRF_Fwd_Frc	0.01	0.01	61.98	1.45	0.00	0.00	64.26	1.44	0.01	0.01
L_GRF_Fwd_Frc	0.01	0.01	62.16	1.22	0.00	0.00	64.44	0.98	0.01	0.01
R_GRF_Lat_Frc	0.00	0.01	63.35	2.11	0.00	0.00	63.26	1.29	0.00	0.01
L_GRF_Lat_Frc	0.00	0.00	63.62	1.49	0.00	0.00	62.80	1.33	0.00	0.00
R_GRF_Vrt_Frc	0.05	0.02	61.89	1.28	0.00	0.00	64.62	1.35	0.05	0.02
L_GRF_Vrt_Frc	0.06	0.03	61.71	0.95	0.00	0.00	64.89	0.91	0.06	0.03
R_Hip_Rot_Mom	0.01	0.01	80.71	6.60	-0.03	0.01	69.07	12.79	-0.02	0.01
L_Hip_Rot_Mom	0.01	0.01	85.25	2.62	-0.04	0.01	66.16	4.53	-0.02	0.02
R_Hip_Abd_Mom	0.10	0.04	91.80	11.89	-0.07	0.04	66.80	10.19	-0.05	0.06
L_Hip_Abd_Mom	0.09	0.03	93.62	5.64	-0.07	0.03	64.44	4.19	-0.05	0.05
R_Hip_Flex_Mom	0.36	0.06	95.80	0.88	-0.30	0.08	61.89	1.28	-0.30	0.08
L_Hip_Flex_Mom	0.30	0.08	95.89	1.42	-0.24	0.07	61.71	0.95	-0.24	0.07
R_Knee_Rot_Mom	0.01	0.00	63.80	2.00	-0.01	0.00	83.71	14.41	0.00	0.01
L_Knee_Rot_Mom	0.01	0.00	64.53	2.95	-0.01	0.01	79.44	16.48	0.00	0.02
R_Knee_Abd_Mom	0.08	0.05	96.89	1.49	-0.04	0.02	63.44	1.54	-0.03	0.02
L_Knee_Abd_Mom	0.05	0.02	89.62	13.91	-0.04	0.01	69.07	6.35	-0.01	0.02
R_Knee_Flex_Mom	0.11	0.05	61.89	1.28	-0.20	0.03	95.26	0.51	0.11	0.05
L_Knee_Flex_Mom	0.11	0.04	61.71	0.95	-0.14	0.02	95.25	1.21	0.11	0.04
R_Ank_Rot_Mom	0.01	0.00	86.16	12.44	-0.01	0.00	63.98	1.87	0.00	0.01
L_Ank_Rot_Mom	0.01	0.01	79.89	16.94	-0.01	0.00	64.44	2.99	0.00	0.02
R_Ank_Abd_Mom	0.01	0.01	76.16	16.63	0.00	0.00	64.89	1.56	0.01	0.01
L_Ank_Abd_Mom	0.01	0.01	71.16	15.71	0.00	0.00	65.16	2.35	0.01	0.01
R_Ank_Flex_Mom	0.06	0.04	65.16	10.84	-0.04	0.01	66.07	1.14	0.06	0.04
L_Ank_Flex_Mom	0.08	0.05	61.71	0.95	-0.03	0.01	66.07	0.94	0.08	0.05
R_Hip_Pwr	0.69	0.24	63.07	2.31	-0.02	0.03	87.35	4.06	0.66	0.20
L_Hip_Pwr	0.61	0.22	62.53	2.03	0.00	0.01	85.89	1.27	0.59	0.20
R_Knee_Pwr	0.05	0.03	74.44	4.56	-0.89	0.25	83.53	14.13	-0.61	0.27
L_Knee_Pwr	0.03	0.05	76.53	11.42	-0.79	0.24	82.34	13.58	-0.62	0.25
R_Ank_Pwr	0.16	0.12	63.35	3.80	-0.02	0.03	77.89	10.95	0.15	0.12
L_Ank_Pwr	0.23	0.16	61.71	0.95	-0.02	0.02	75.07	11.70	0.23	0.16

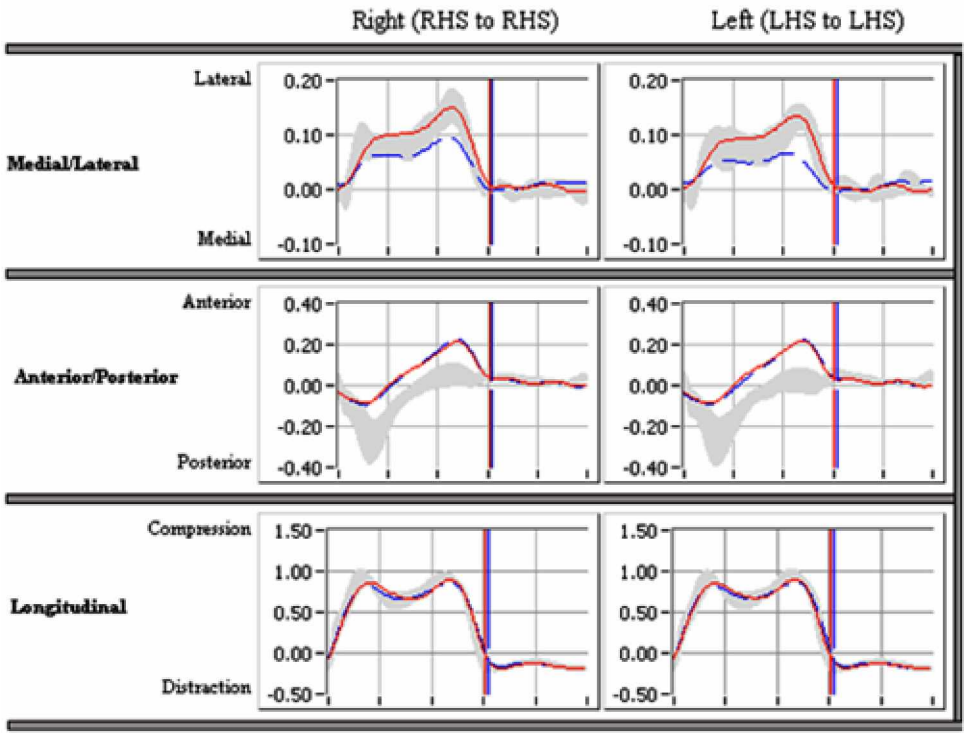

Figure C.49 Hip Joint Forces (N), 18-year-old subjects.

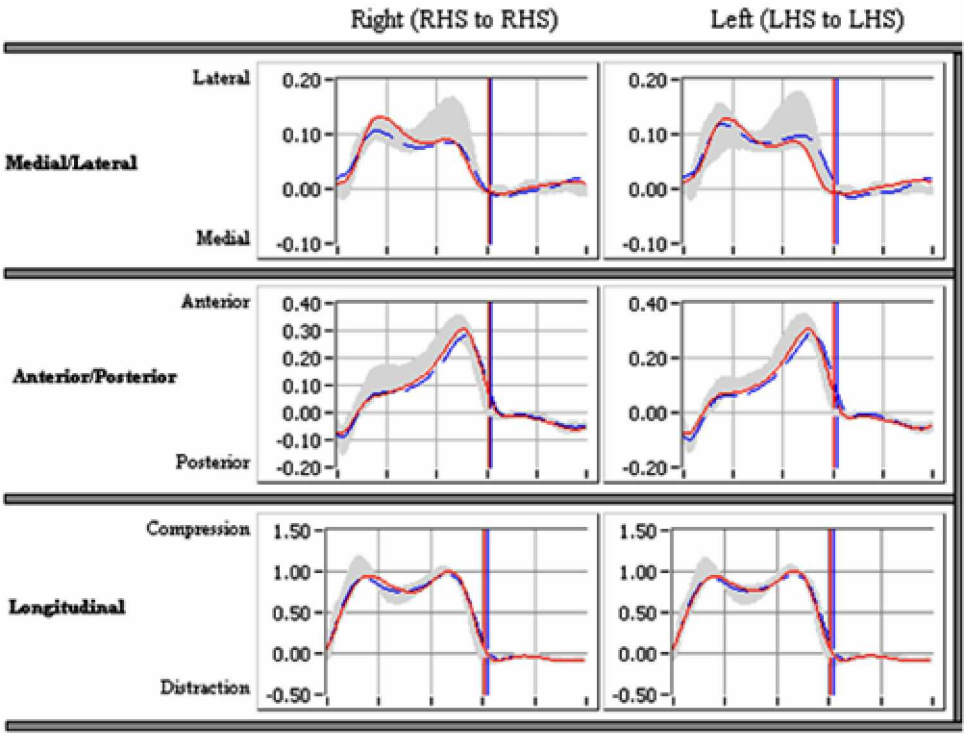

Figure C.50 Knee Joint Forces (N), 18-year-old subjects.

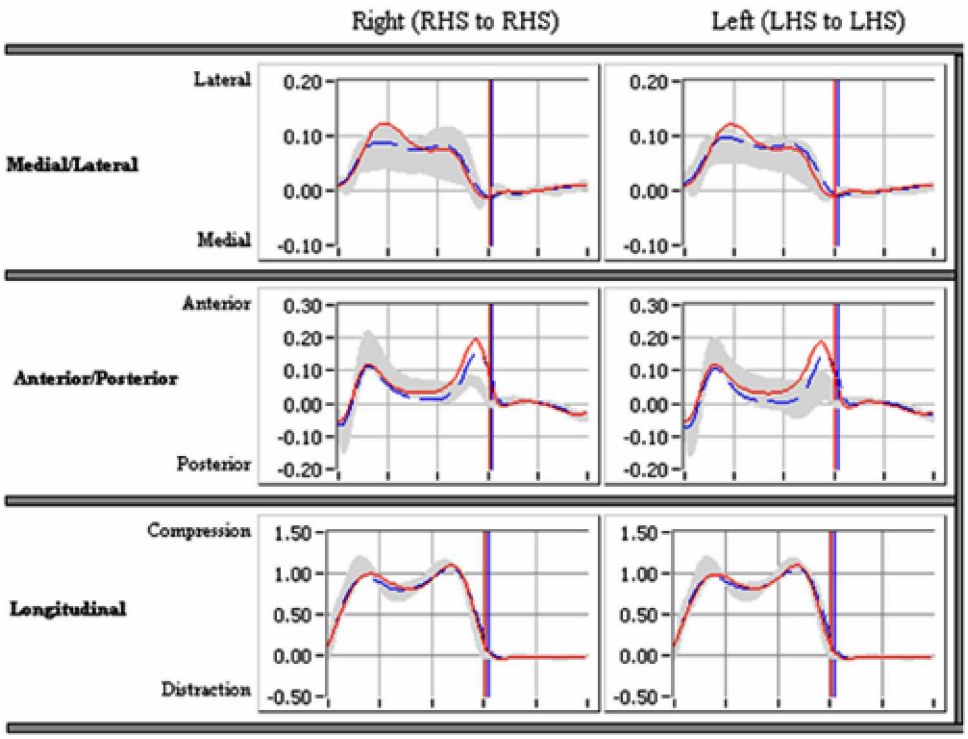

Figure C.51 Ankle Joint Forces (N), 18-year-old subjects.

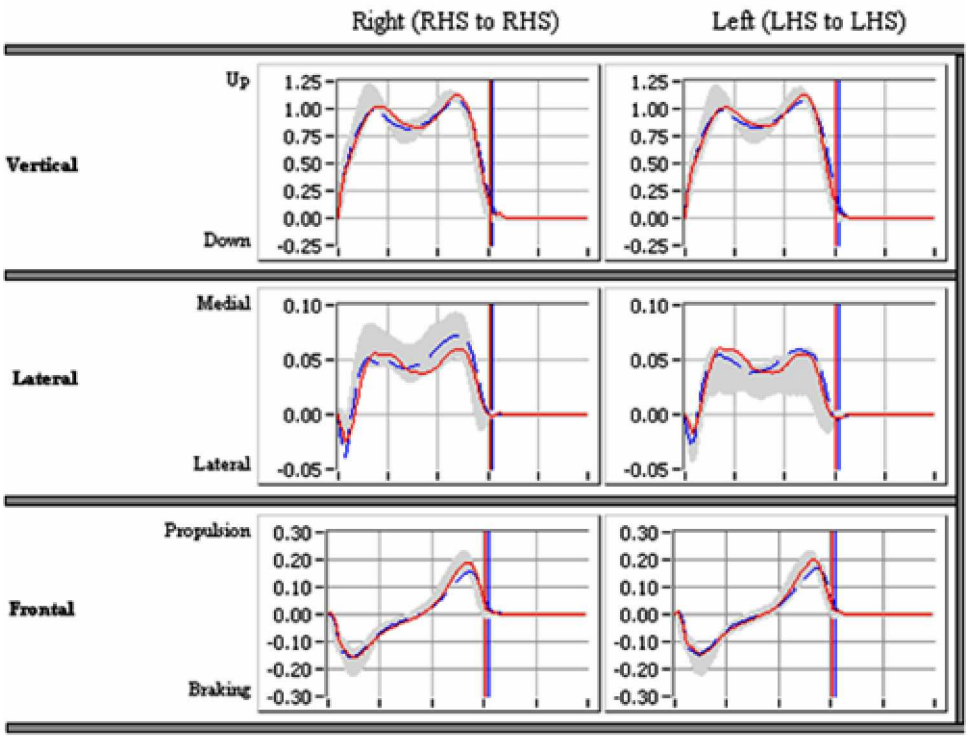

Figure C.52 Ground Reaction Forces (N), 18-year-old subjects.

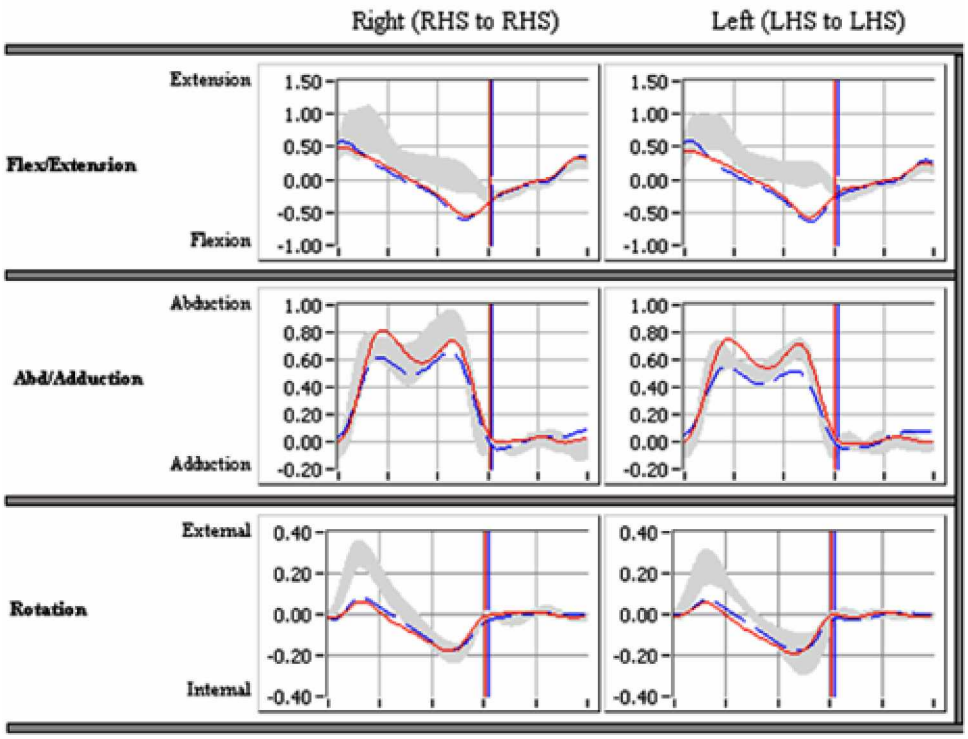

Figure C.53 Hip Joint Moments (Nm/Kg), 18-year-old subjects.

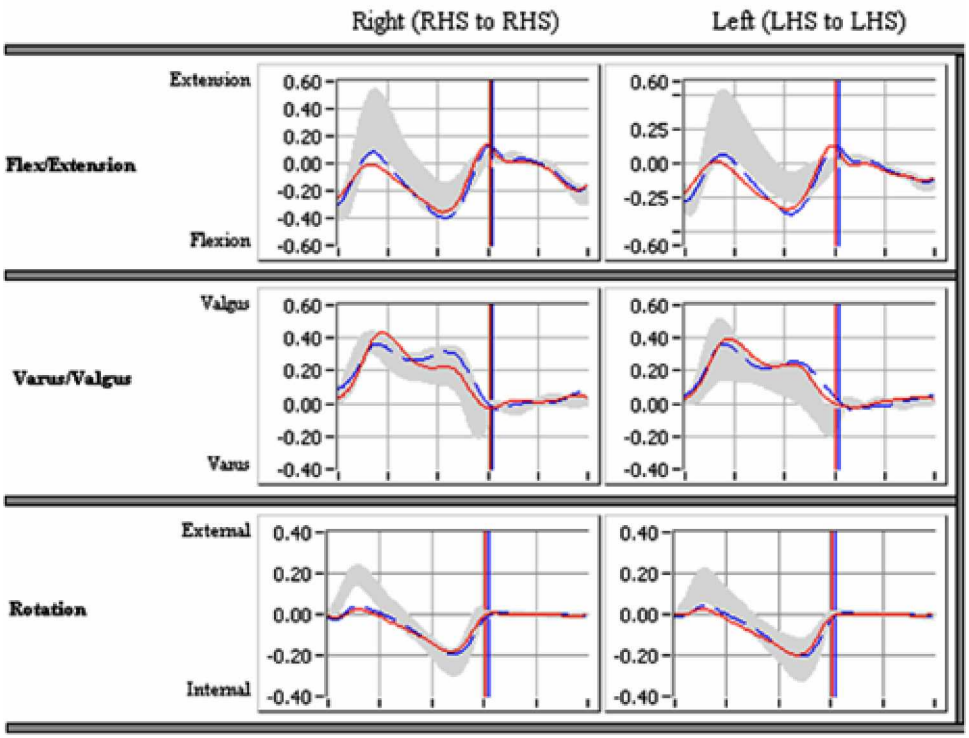

Figure C.54 Knee Joint Moments (Nm/Kg), 18-year-old subjects.

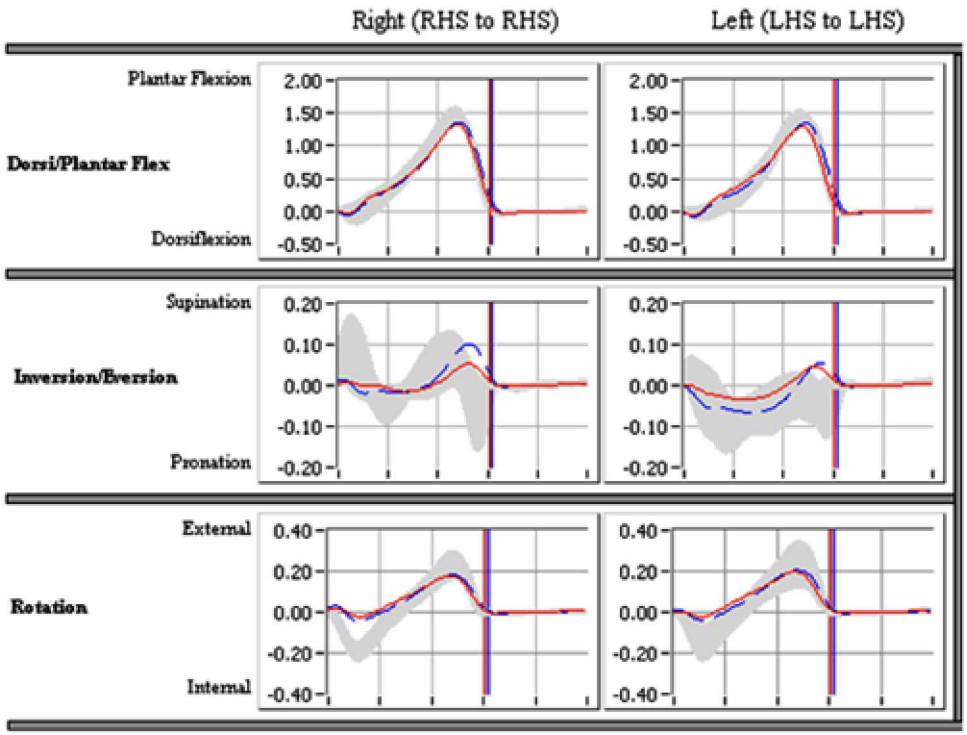

Figure C.55 Ankle Joint Moments (Nm/Kg), 18-year-old subjects.

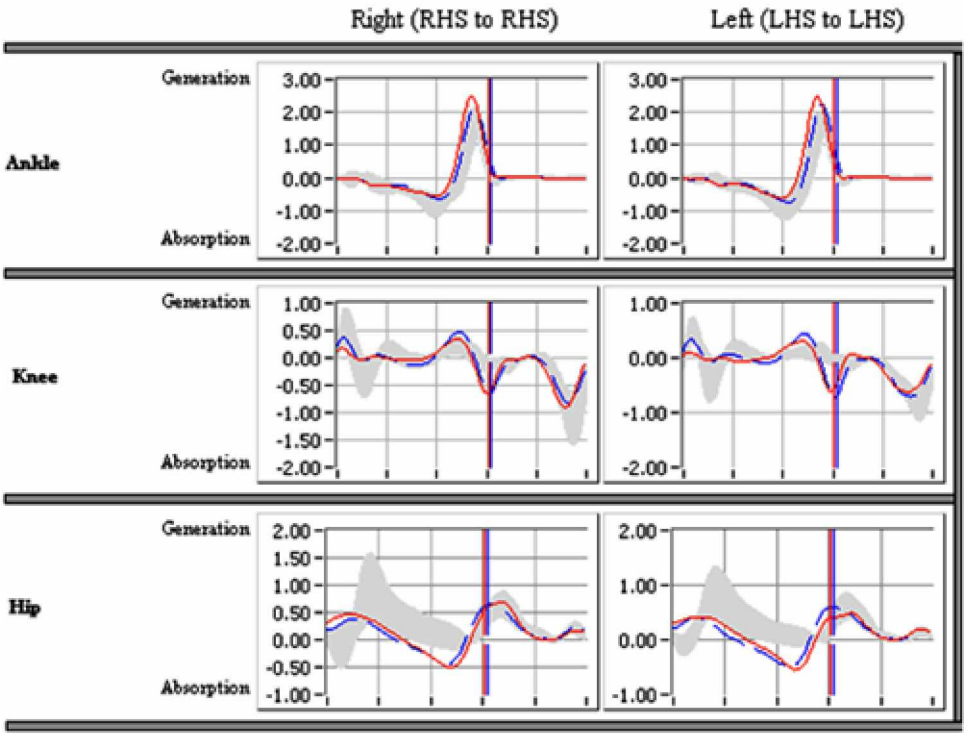

Figure C.56 Sagittal Joint Powers (Watts/Kg), 18-year-old subjects.

Table C.29 Stance Phase Kinetics of 20-year-old Female Subjects.

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	-0.05	0.02	0.91	0.03	38.30	14.51	-0.06	0.02	36.90	31.77
L_Hip_Rot_Frc	-0.05	0.02	0.93	0.02	41.20	12.25	-0.06	0.04	12.40	26.14
R_Hip_Abd_Frc	-0.04	0.01	0.30	0.04	46.00	0.94	-0.11	0.04	7.50	3.24
L_Hip_Abd_Frc	-0.04	0.02	0.29	0.04	46.00	0.00	-0.11	0.04	9.00	2.00
R_Hip_Flex_Frc	0.00	0.01	0.12	0.03	30.10	14.46	0.00	0.01	25.30	30.53
L_Hip_Flex_Frc	0.00	0.01	0.12	0.02	30.60	14.01	-0.01	0.01	7.20	18.61
R_Knee_Rot_Frc	0.08	0.02	0.98	0.04	34.60	15.62	0.03	0.02	61.10	1.10
L_Knee_Rot_Frc	0.08	0.03	1.00	0.03	37.50	14.18	0.05	0.05	42.50	29.34
R_Knee_Abd_Frc	-0.06	0.01	0.42	0.08	50.30	1.49	-0.07	0.01	0.30	0.48
L_Knee_Abd_Frc	-0.07	0.01	0.43	0.08	50.00	0.00	-0.07	0.01	0.60	0.97
R_Knee_Flex_Frc	0.00	0.01	0.16	0.04	23.40	13.28	0.00	0.01	19.10	28.49
L_Knee_Flex_Frc	0.00	0.01	0.13	0.03	26.10	14.75	-0.01	0.01	32.70	27.39
R_Ank_Rot_Frc	0.15	0.02	1.09	0.04	43.60	9.37	0.07	0.02	61.10	1.10
L_Ank_Rot_Frc	0.14	0.03	1.12	0.04	46.50	0.53	0.11	0.05	48.50	25.57
R_Ank_Abd_Frc	-0.04	0.01	0.35	0.08	53.70	1.06	-0.04	0.01	0.00	0.00
L_Ank_Abd_Frc	-0.05	0.01	0.34	0.07	53.80	0.63	-0.05	0.01	0.20	0.42
R_Ank_Flex_Frc	0.00	0.00	0.12	0.03	21.30	7.32	-0.01	0.01	41.00	28.32
L_Ank_Flex_Frc	0.00	0.00	0.09	0.01	23.30	9.10	-0.01	0.01	53.40	18.08
R_GRF_Fwd_Frc	0.00	0.00	0.20	0.02	54.10	0.57	-0.17	0.03	10.20	1.14
L_GRF_Fwd_Frc	0.00	0.01	0.21	0.00	53.80	0.79	-0.15	0.03	10.70	0.82
R_GRF_Lat_Frc	0.00	0.00	0.07	0.02	27.70	13.18	-0.03	0.01	3.10	0.74
L_GRF_Lat_Frc	0.00	0.00	0.07	0.02	17.90	3.57	-0.02	0.01	3.70	0.82
R_GRF_Vrt_Frc	0.00	0.00	1.14	0.05	38.30	14.51	0.00	0.00	0.00	0.00
L_GRF_Vrt_Frc	0.01	0.04	1.16	0.05	41.10	12.71	0.01	0.03	6.00	18.97
R_Hip_Rot_Mom	-0.02	0.01	0.14	0.11	21.80	17.61	-0.15	0.02	42.40	2.17
L_Hip_Rot_Mom	-0.01	0.01	0.11	0.07	26.90	21.02	-0.18	0.02	42.90	1.97
R_Hip_Abd_Mom	0.04	0.05	0.87	0.02	20.10	9.15	-0.04	0.03	43.00	29.69
L_Hip_Abd_Mom	-0.03	0.04	0.78	0.10	20.80	8.93	-0.03	0.03	12.00	25.30
R_Hip_Flex_Mom	0.42	0.07	0.42	0.07	1.30	4.11	-1.17	0.26	49.40	1.07
L_Hip_Flex_Mom	0.40	0.08	0.41	0.09	0.60	0.97	-1.18	0.27	49.10	0.32
R_Knee_Rot_Mom	-0.01	0.02	0.07	0.08	25.50	22.22	-0.17	0.03	44.90	3.07
L_Knee_Rot_Mom	-0.01	0.00	0.04	0.03	25.50	23.75	-0.19	0.02	44.60	2.12
R_Knee_Abd_Mom	0.02	0.04	0.46	0.06	16.50	1.18	0.00	0.03	18.30	29.01
L_Knee_Abd_Mom	-0.01	0.03	0.35	0.06	19.20	8.08	-0.01	0.03	0.10	0.32
R_Knee_Flex_Mom	-0.18	0.05	0.50	0.20	47.50	17.30	-0.25	0.13	15.80	20.47
L_Knee_Flex_Mom	-0.18	0.06	0.52	0.23	51.20	13.26	-0.24	0.14	15.00	19.37
R_Ank_Rot_Mom	0.01	0.02	0.17	0.05	43.90	3.07	-0.07	0.08	25.40	22.53
L_Ank_Rot_Mom	0.01	0.00	0.20	0.03	44.00	2.26	-0.04	0.03	25.40	23.59
R_Ank_Abd_Mom	0.01	0.01	0.10	0.07	37.50	24.51	-0.05	0.03	35.50	12.25
L_Ank_Abd_Mom	0.00	0.00	0.06	0.04	53.90	4.61	-0.05	0.03	21.90	6.52
R_Ank_Flex_Mom	-0.02	0.01	1.37	0.16	47.10	1.29	-0.08	0.03	3.00	0.00
L_Ank_Flex_Mom	-0.02	0.02	1.37	0.13	46.40	0.52	-0.07	0.04	3.50	0.85
R_Hip_Pwr	0.13	0.07	1.61	0.65	57.30	2.31	-0.87	0.23	41.70	2.71
L_Hip_Pwr	0.26	0.08	1.55	0.77	57.60	2.50	-0.93	0.20	42.40	2.72
R_Knee_Pwr	0.22	0.11	0.53	0.20	24.00	16.69	-2.78	1.47	56.90	2.18
L_Knee_Pwr	0.17	0.09	0.61	0.29	25.90	13.19	-3.01	1.47	56.80	1.87
R_Ank_Pwr	-0.01	0.01	3.20	0.83	51.60	1.90	-0.67	0.10	37.00	2.83
L_Ank_Pwr	0.00	0.01	3.18	0.51	51.30	1.25	-0.63	0.29	32.40	8.25

Table C.30 Swing Phase Kinetics of 20-year-old Female Subjects.

	Maximum Swing		Time of Max. Sw.		Minimum Swing		Time of Min. Sw.		Toe Off	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	-0.10	0.02	63.02	3.86	-0.20	0.01	98.12	0.53	-0.10	0.02
L_Hip_Rot_Frc	-0.08	0.04	63.91	6.71	-0.20	0.01	97.71	1.45	-0.08	0.05
R_Hip_Abd_Frc	0.03	0.01	64.82	1.61	-0.01	0.01	91.82	7.90	0.02	0.02
L_Hip_Abd_Frc	0.04	0.01	70.71	8.24	0.00	0.01	92.61	7.59	0.02	0.01
R_Hip_Flex_Frc	0.01	0.01	82.72	8.80	-0.01	0.01	77.72	13.48	0.00	0.01
L_Hip_Flex_Frc	0.01	0.01	72.91	7.86	-0.01	0.01	81.41	12.04	0.01	0.01
R_Knee_Rot_Frc	-0.01	0.02	61.72	1.11	-0.09	0.00	88.32	1.42	-0.01	0.02
L_Knee_Rot_Frc	0.01	0.04	63.31	5.45	-0.09	0.00	86.91	7.59	0.01	0.04
R_Knee_Abd_Frc	0.04	0.01	61.72	1.11	-0.06	0.01	90.62	2.06	0.04	0.01
L_Knee_Abd_Frc	0.05	0.02	61.11	0.86	-0.07	0.01	90.31	2.91	0.05	0.02
R_Knee_Flex_Frc	0.02	0.01	79.72	15.84	-0.01	0.01	65.62	1.90	0.01	0.01
L_Knee_Flex_Frc	0.02	0.01	78.41	15.23	-0.01	0.01	67.31	3.66	0.01	0.01
R_Ank_Rot_Frc	0.03	0.01	61.72	1.11	-0.04	0.00	66.42	0.93	0.03	0.01
L_Ank_Rot_Frc	0.05	0.04	61.11	0.86	-0.04	0.00	66.41	0.42	0.05	0.04
R_Ank_Abd_Frc	0.06	0.01	61.72	1.11	-0.03	0.00	91.62	1.70	0.06	0.01
L_Ank_Abd_Frc	0.08	0.03	61.11	0.86	-0.03	0.00	92.01	1.51	0.08	0.03
R_Ank_Flex_Frc	0.01	0.00	87.62	5.58	-0.01	0.00	62.02	1.18	-0.01	0.00
L_Ank_Flex_Frc	0.01	0.00	88.31	4.35	-0.01	0.00	61.31	0.96	-0.01	0.00
R_GRF_Fwd_Frc	0.00	0.00	61.72	1.11	0.00	0.00	63.42	1.56	0.00	0.00
L_GRF_Fwd_Frc	0.01	0.01	61.51	1.67	0.00	0.00	63.21	0.84	0.01	0.01
R_GRF_Lat_Frc	0.00	0.00	62.12	1.09	0.00	0.00	63.12	1.72	0.00	0.00
L_GRF_Lat_Frc	0.00	0.00	62.51	0.74	0.00	0.00	61.51	1.67	0.00	0.00
R_GRF_Vrt_Frc	0.03	0.01	61.72	1.11	0.00	0.00	63.92	1.17	0.03	0.01
L_GRF_Vrt_Frc	0.05	0.02	61.11	0.86	0.00	0.00	63.81	1.04	0.05	0.02
R_Hip_Rot_Mom	0.02	0.01	71.42	4.49	-0.01	0.01	82.62	10.98	0.00	0.01
L_Hip_Rot_Mom	0.02	0.01	79.81	3.91	-0.03	0.01	65.21	1.58	-0.01	0.01
R_Hip_Abd_Mom	0.07	0.05	79.92	14.95	-0.05	0.04	70.92	12.48	-0.02	0.06
L_Hip_Abd_Mom	0.05	0.02	78.11	9.46	-0.05	0.03	81.81	14.20	0.00	0.03
R_Hip_Flex_Mom	0.33	0.07	93.32	0.96	-0.33	0.06	61.72	1.11	-0.33	0.06
L_Hip_Flex_Mom	0.26	0.06	93.11	1.08	-0.29	0.02	61.11	0.86	-0.29	0.02
R_Knee_Rot_Mom	0.01	0.00	63.92	3.10	-0.01	0.00	79.12	12.22	0.00	0.01
L_Knee_Rot_Mom	0.01	0.01	62.91	1.50	-0.01	0.00	83.51	8.51	0.00	0.01
R_Knee_Abd_Mom	0.09	0.01	74.12	15.52	-0.01	0.01	81.02	14.90	0.05	0.04
L_Knee_Abd_Mom	0.05	0.02	72.21	14.16	-0.03	0.01	66.81	0.93	0.04	0.03
R_Knee_Flex_Mom	0.19	0.03	61.72	1.11	-0.20	0.02	91.92	1.65	0.19	0.03
L_Knee_Flex_Mom	0.21	0.07	61.11	0.86	-0.15	0.02	91.01	2.59	0.21	0.07
R_Ank_Rot_Mom	0.01	0.00	80.22	13.20	-0.01	0.00	63.22	1.78	0.00	0.01
L_Ank_Rot_Mom	0.00	0.00	82.01	8.10	-0.01	0.01	62.91	1.50	0.00	0.01
R_Ank_Abd_Mom	0.01	0.00	62.62	1.77	-0.01	0.00	63.82	2.05	0.00	0.01
L_Ank_Abd_Mom	0.01	0.01	68.81	12.98	0.00	0.00	65.41	1.76	0.01	0.01
R_Ank_Flex_Mom	0.02	0.01	61.72	1.11	-0.04	0.01	65.72	1.11	0.02	0.01
L_Ank_Flex_Mom	0.05	0.03	67.71	14.72	-0.04	0.01	65.61	0.47	0.05	0.03
R_Hip_Pwr	0.98	0.10	62.02	1.44	-0.02	0.02	84.82	6.27	0.97	0.09
L_Hip_Pwr	1.01	0.24	61.51	1.67	-0.05	0.05	83.61	4.24	1.01	0.25
R_Knee_Pwr	0.12	0.07	96.12	7.91	-1.01	0.14	69.52	13.22	-0.98	0.17
L_Knee_Pwr	0.11	0.07	86.91	15.30	-1.33	0.30	68.51	12.77	-1.28	0.37
R_Ank_Pwr	0.07	0.03	66.52	2.09	-0.01	0.00	83.72	1.73	0.04	0.04
L_Ank_Pwr	0.10	0.05	62.71	3.18	-0.01	0.00	86.01	4.55	0.09	0.06

Table C.31 Stance Phase Kinetics of 20-year-old Male Subjects.

	Foot Strike		Maximum Stance		Time of Max. St.		Minimum Stance		Time of Min. St.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	-0.05	0.04	0.89	0.03	39.56	14.84	-0.08	0.03	20.67	31.00
L_Hip_Rot_Frc	-0.06	0.04	0.89	0.04	29.11	17.50	-0.08	0.02	27.11	32.15
R_Hip_Abd_Frc	-0.03	0.02	0.24	0.03	47.44	0.73	-0.10	0.04	8.33	4.33
L_Hip_Abd_Frc	-0.04	0.02	0.24	0.04	47.44	0.88	-0.09	0.04	8.33	3.20
R_Hip_Flex_Frc	0.01	0.01	0.08	0.03	39.89	11.32	-0.01	0.00	21.00	28.08
L_Hip_Flex_Frc	0.01	0.01	0.06	0.01	39.11	9.25	-0.01	0.01	33.67	28.63
R_Knee_Rot_Frc	0.06	0.04	0.99	0.04	35.67	16.79	0.02	0.03	41.00	30.76
L_Knee_Rot_Frc	0.06	0.04	0.99	0.05	39.22	15.29	0.03	0.02	47.67	27.03
R_Knee_Abd_Frc	-0.08	0.02	0.30	0.04	51.11	0.93	-0.09	0.02	2.33	0.71
L_Knee_Abd_Frc	-0.09	0.02	0.29	0.04	51.11	0.78	-0.10	0.02	2.44	0.73
R_Knee_Flex_Frc	0.02	0.02	0.13	0.03	19.11	9.64	-0.02	0.01	45.89	26.10
L_Knee_Flex_Frc	0.02	0.02	0.13	0.02	23.78	14.10	0.00	0.01	41.33	29.25
R_Ank_Rot_Frc	0.13	0.04	1.07	0.05	39.67	15.17	0.08	0.03	41.00	30.76
L_Ank_Rot_Frc	0.12	0.05	1.07	0.06	43.11	12.55	0.09	0.03	40.89	30.67
R_Ank_Abd_Frc	-0.06	0.01	0.17	0.02	55.56	0.73	-0.07	0.01	0.89	0.60
L_Ank_Abd_Frc	-0.07	0.01	0.16	0.03	56.22	1.09	-0.07	0.01	1.33	0.50
R_Ank_Flex_Frc	0.01	0.01	0.12	0.03	25.67	13.78	-0.01	0.01	60.00	1.00
L_Ank_Flex_Frc	0.01	0.01	0.12	0.02	19.33	9.84	-0.01	0.01	60.78	1.20
R_GRF_Fwd_Frc	0.00	0.00	0.16	0.02	54.22	0.97	-0.17	0.03	9.33	2.12
L_GRF_Fwd_Frc	0.00	0.00	0.17	0.02	54.67	0.87	-0.15	0.02	9.22	2.77
R_GRF_Lat_Frc	0.00	0.00	0.07	0.02	41.89	12.90	-0.04	0.01	3.22	1.86
L_GRF_Lat_Frc	0.00	0.00	0.06	0.02	22.44	16.55	-0.04	0.01	3.00	0.00
R_GRF_Vrt_Frc	0.00	0.00	1.10	0.05	39.89	15.58	0.00	0.00	0.00	0.00
L_GRF_Vrt_Frc	0.00	0.00	1.10	0.06	39.44	16.40	0.00	0.00	0.00	0.00
R_Hip_Rot_Mom	-0.01	0.01	0.06	0.06	22.00	21.48	-0.16	0.04	44.11	2.42
L_Hip_Rot_Mom	0.01	0.01	0.05	0.04	12.56	17.94	-0.20	0.05	44.78	3.03
R_Hip_Abd_Mom	0.01	0.09	0.72	0.08	29.33	15.26	-0.05	0.06	27.22	32.29
L_Hip_Abd_Mom	0.01	0.07	0.65	0.10	26.78	15.33	-0.05	0.03	34.11	31.89
R_Hip_Flex_Mom	0.59	0.14	0.61	0.14	2.33	2.65	-0.69	0.10	51.33	3.39
L_Hip_Flex_Mom	0.59	0.11	0.62	0.11	2.11	0.60	-0.61	0.15	49.78	1.39
R_Knee_Rot_Mom	-0.03	0.01	0.03	0.04	44.33	25.01	-0.18	0.04	45.11	2.42
L_Knee_Rot_Mom	-0.01	0.00	0.02	0.04	50.00	22.15	-0.23	0.05	45.56	3.09
R_Knee_Abd_Mom	0.10	0.09	0.49	0.13	29.11	14.23	-0.03	0.03	47.33	26.84
L_Knee_Abd_Mom	0.05	0.06	0.46	0.14	22.11	13.64	0.00	0.02	40.78	30.34
R_Knee_Flex_Mom	-0.31	0.04	0.18	0.09	44.00	23.77	-0.43	0.10	32.56	18.58
L_Knee_Flex_Mom	-0.29	0.05	0.13	0.04	49.56	20.46	-0.45	0.13	28.78	21.38
R_Ank_Rot_Mom	0.03	0.01	0.17	0.04	44.11	3.02	-0.03	0.04	44.33	25.01
L_Ank_Rot_Mom	0.01	0.00	0.22	0.04	44.89	3.06	-0.02	0.04	50.00	22.18
R_Ank_Abd_Mom	0.01	0.01	0.11	0.06	53.11	1.96	-0.02	0.02	21.67	11.74
L_Ank_Abd_Mom	0.00	0.01	0.10	0.06	54.33	2.78	-0.05	0.04	19.67	15.04
R_Ank_Flex_Mom	-0.01	0.01	1.41	0.07	48.11	0.93	-0.07	0.02	3.78	0.67
L_Ank_Flex_Mom	-0.01	0.01	1.42	0.13	48.67	1.00	-0.08	0.04	3.44	0.73
R_Hip_Pwr	0.25	0.37	0.74	0.16	42.56	27.35	-0.55	0.12	46.11	1.27
L_Hip_Pwr	0.27	0.18	0.58	0.12	43.56	25.99	-0.44	0.12	45.67	1.73
R_Knee_Pwr	0.17	0.40	0.61	0.30	33.56	23.69	-0.76	0.11	60.22	1.20
L_Knee_Pwr	0.16	0.22	0.71	0.29	28.67	24.15	-0.72	0.17	60.22	0.97
R_Ank_Pwr	-0.01	0.01	2.23	0.51	54.67	1.12	-0.72	0.29	40.44	2.51
L_Ank_Pwr	-0.01	0.01	2.33	0.61	55.11	0.78	-0.81	0.17	40.33	4.77

Table C.32 Swing Phase Kinetics of 20-year-old Male Subjects.

	Maximum Swing		Time of Max. Sw.		Minimum Swing		Time of Min. Sw.		Toe Off	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
R_Hip_Rot_Frc	-0.10	0.01	69.73	7.29	-0.20	0.01	93.84	11.36	-0.11	0.02
L_Hip_Rot_Frc	-0.10	0.03	66.51	6.86	-0.19	0.01	93.73	11.41	-0.10	0.04
R_Hip_Abd_Frc	0.04	0.01	68.62	9.18	-0.01	0.01	92.62	6.31	0.03	0.01
L_Hip_Abd_Frc	0.03	0.01	68.62	9.13	-0.01	0.01	93.40	7.63	0.03	0.01
R_Hip_Flex_Frc	0.02	0.01	94.40	6.51	0.00	0.00	68.51	9.47	0.00	0.00
L_Hip_Flex_Frc	0.02	0.01	98.51	0.34	0.00	0.01	67.06	4.69	0.00	0.01
R_Knee_Rot_Frc	-0.02	0.01	64.51	5.51	-0.09	0.00	91.84	2.38	-0.02	0.02
L_Knee_Rot_Frc	-0.01	0.03	68.51	6.55	-0.09	0.00	91.62	2.50	-0.01	0.03
R_Knee_Abd_Frc	0.03	0.02	61.84	0.84	-0.06	0.01	93.17	1.13	0.03	0.02
L_Knee_Abd_Frc	0.04	0.02	61.84	0.67	-0.06	0.01	93.95	1.58	0.04	0.02
R_Knee_Flex_Frc	0.02	0.01	88.40	15.20	-0.02	0.00	66.84	8.53	-0.01	0.01
L_Knee_Flex_Frc	0.02	0.01	97.29	1.42	-0.02	0.00	65.62	1.50	-0.01	0.00
R_Ank_Rot_Frc	0.04	0.02	61.84	0.84	-0.04	0.00	66.17	0.89	0.04	0.02
L_Ank_Rot_Frc	0.05	0.04	61.84	0.67	-0.04	0.00	66.51	0.78	0.05	0.04
R_Ank_Abd_Frc	0.04	0.01	61.84	0.84	-0.03	0.00	95.29	0.50	0.04	0.01
L_Ank_Abd_Frc	0.04	0.02	61.84	0.67	-0.03	0.00	95.95	0.71	0.04	0.02
R_Ank_Flex_Frc	0.01	0.00	95.51	0.93	-0.01	0.00	63.29	3.20	-0.01	0.00
L_Ank_Flex_Frc	0.01	0.00	95.29	1.12	-0.01	0.00	62.51	1.06	-0.01	0.00
R_GRF_Fwd_Frc	0.01	0.01	61.84	0.84	0.00	0.00	64.06	1.24	0.01	0.01
L_GRF_Fwd_Frc	0.01	0.01	62.06	0.53	0.00	0.00	64.40	0.83	0.01	0.01
R_GRF_Lat_Frc	0.00	0.00	63.17	1.59	0.00	0.00	62.95	1.59	0.00	0.00
L_GRF_Lat_Frc	0.00	0.00	64.51	0.60	0.00	0.00	62.06	0.53	0.00	0.00
R_GRF_Vrt_Frc	0.05	0.03	61.84	0.84	0.00	0.00	64.51	1.17	0.05	0.03
L_GRF_Vrt_Frc	0.05	0.01	61.84	0.67	0.00	0.00	64.62	0.71	0.05	0.01
R_Hip_Rot_Mom	0.01	0.00	84.51	8.59	-0.02	0.01	67.62	9.92	-0.01	0.01
L_Hip_Rot_Mom	0.01	0.01	84.62	1.87	-0.03	0.00	67.06	2.70	-0.01	0.01
R_Hip_Abd_Mom	0.09	0.05	90.40	13.28	-0.05	0.03	64.51	2.52	-0.03	0.05
L_Hip_Abd_Mom	0.08	0.03	93.51	6.18	-0.04	0.03	65.29	3.78	-0.03	0.03
R_Hip_Flex_Mom	0.37	0.07	95.95	0.71	-0.30	0.07	61.84	0.84	-0.30	0.07
L_Hip_Flex_Mom	0.31	0.05	96.62	1.32	-0.22	0.06	61.84	0.67	-0.22	0.06
R_Knee_Rot_Mom	0.01	0.00	62.73	1.54	-0.01	0.00	93.29	1.94	0.01	0.00
L_Knee_Rot_Mom	0.01	0.00	63.06	0.88	-0.01	0.00	89.95	11.12	0.01	0.01
R_Knee_Abd_Mom	0.08	0.04	89.06	15.57	-0.05	0.02	68.62	11.95	-0.03	0.04
L_Knee_Abd_Mom	0.04	0.02	92.29	11.54	-0.04	0.01	67.84	5.31	0.00	0.02
R_Knee_Flex_Mom	0.10	0.03	61.84	0.84	-0.20	0.03	95.40	0.45	0.10	0.03
L_Knee_Flex_Mom	0.09	0.03	61.84	0.67	-0.13	0.03	95.95	1.33	0.09	0.03
R_Ank_Rot_Mom	0.01	0.00	93.62	2.69	-0.01	0.00	62.73	1.46	-0.01	0.00
L_Ank_Rot_Mom	0.01	0.00	90.40	11.31	-0.01	0.01	62.73	0.78	-0.01	0.01
R_Ank_Abd_Mom	0.01	0.01	80.17	17.86	0.00	0.00	65.17	0.73	0.01	0.01
L_Ank_Abd_Mom	0.01	0.01	65.73	11.21	0.00	0.00	65.84	1.65	0.01	0.01
R_Ank_Flex_Mom	0.06	0.03	65.84	11.95	-0.04	0.00	65.84	0.98	0.05	0.03
L_Ank_Flex_Mom	0.07	0.04	61.84	0.67	-0.04	0.00	66.17	0.73	0.07	0.04
R_Hip_Pwr	0.69	0.22	62.40	1.21	-0.01	0.03	86.29	1.00	0.67	0.16
L_Hip_Pwr	0.57	0.19	63.06	1.88	-0.01	0.01	87.40	2.49	0.54	0.16
R_Knee_Pwr	0.07	0.04	75.17	5.30	-0.96	0.13	89.06	9.56	-0.60	0.18
L_Knee_Pwr	0.03	0.06	77.06	12.54	-0.74	0.21	77.62	14.73	-0.59	0.18
R_Ank_Pwr	0.14	0.09	63.62	4.04	-0.03	0.03	78.40	10.93	0.14	0.10
L_Ank_Pwr	0.17	0.08	61.84	0.67	-0.03	0.03	81.84	10.13	0.17	0.08

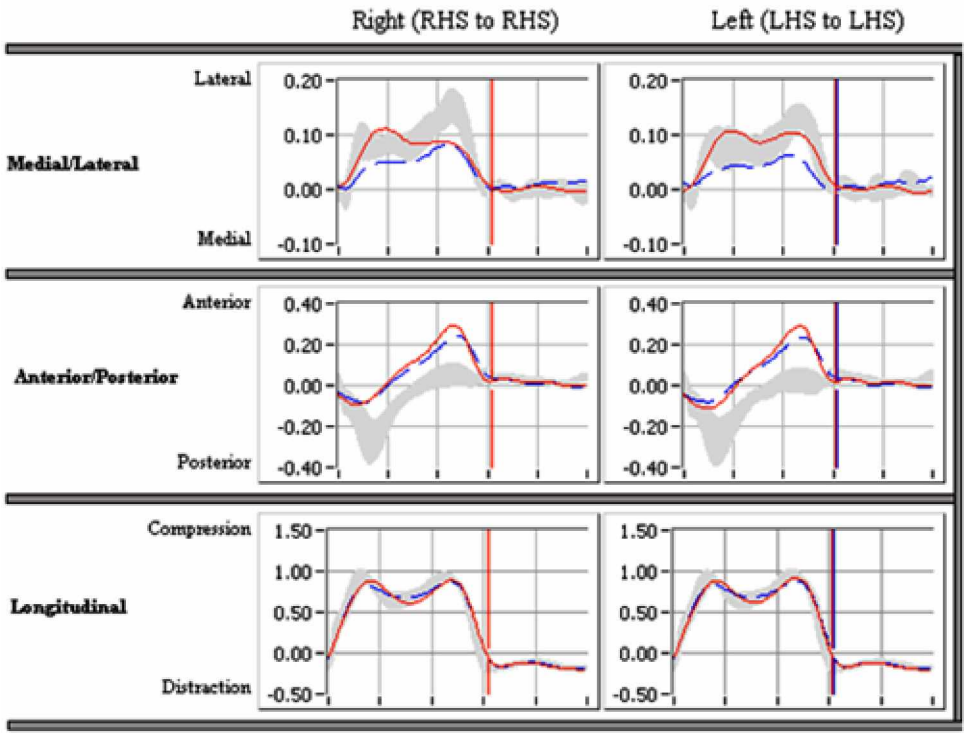

Figure C.57 Hip Joint Forces (N), 20-year-old subjects.

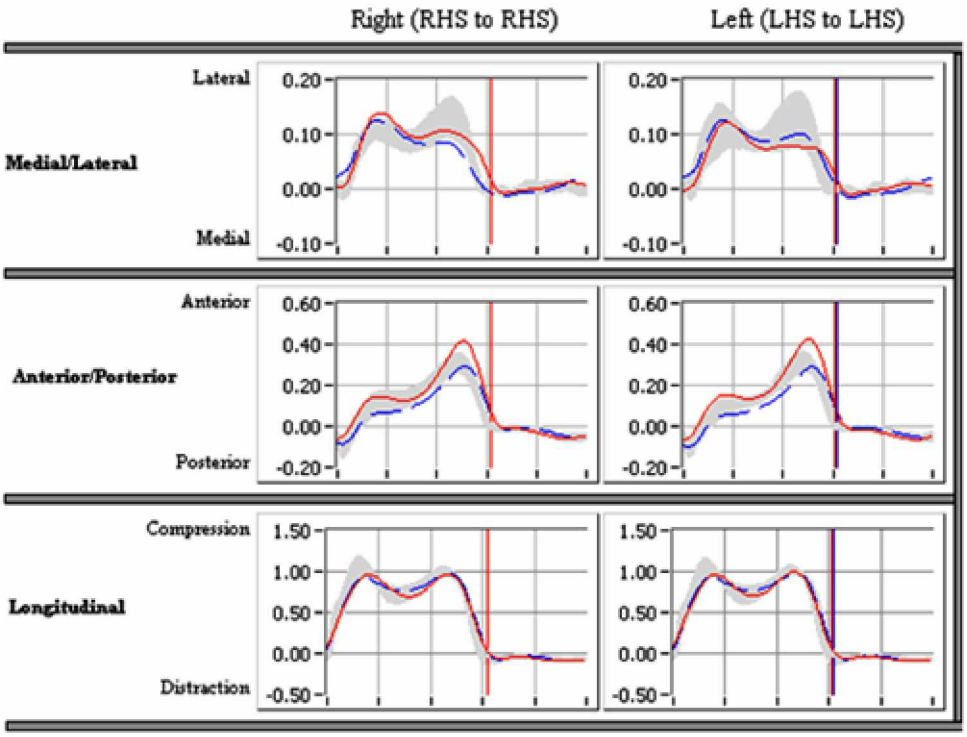

Figure C.58 Knee Joint Forces (N), 20-year-old subjects.

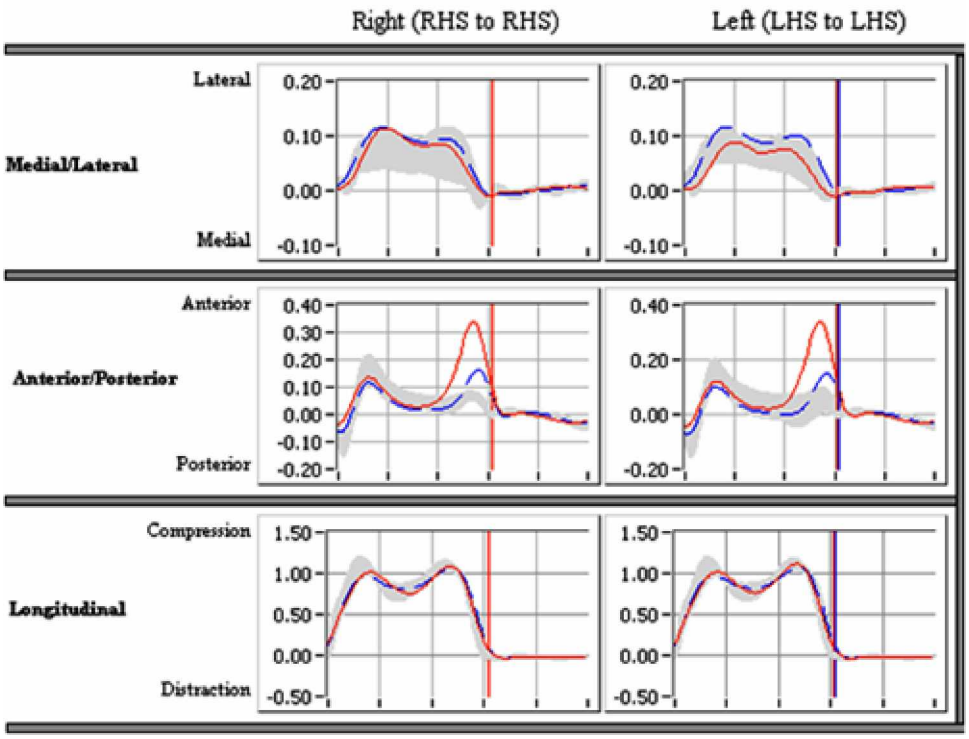

Figure C.59 Ankle Joint Forces (N), 20-year-old subjects.

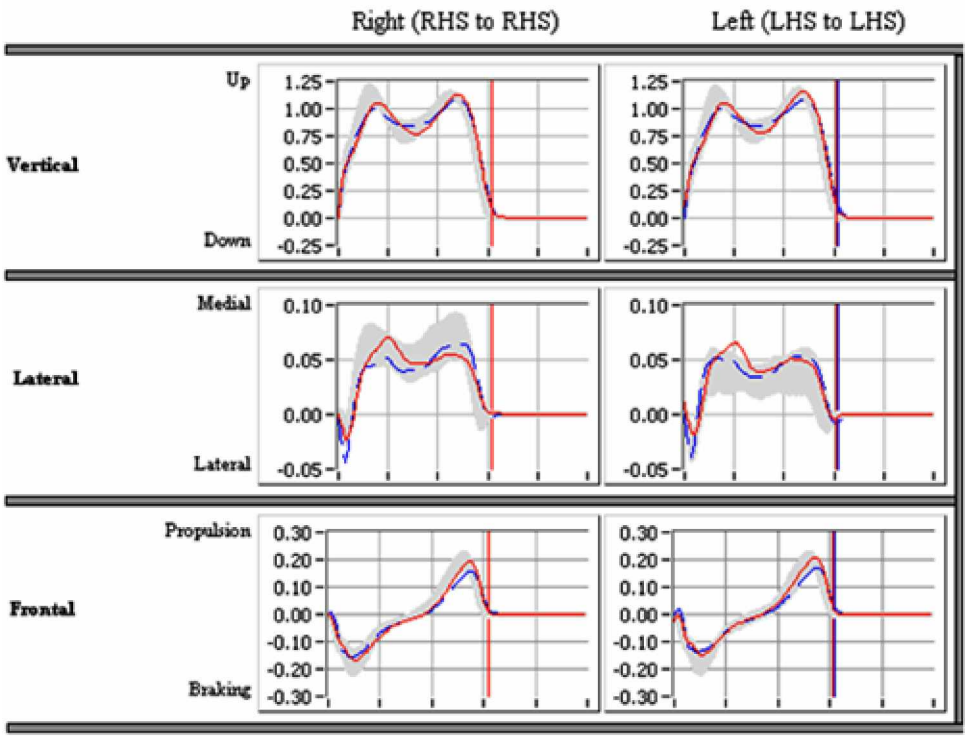

Figure C.60 Ground Reaction Forces (N), 20-year-old subjects.

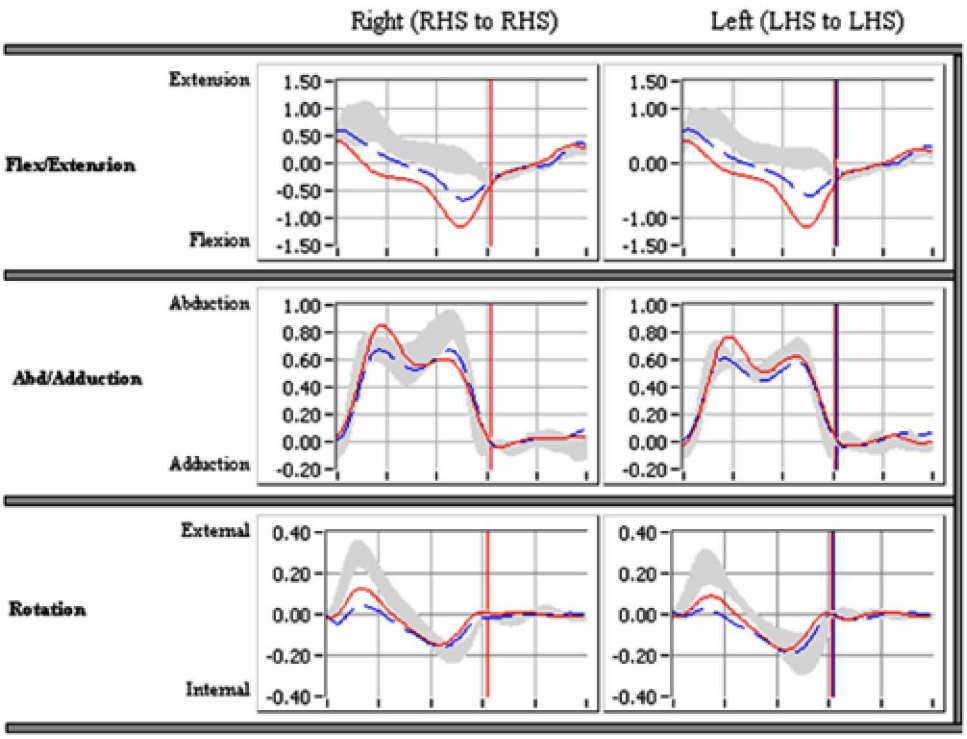

Figure C.61 Hip Joint Moments (Nm/Kg), 20-year-old subjects.

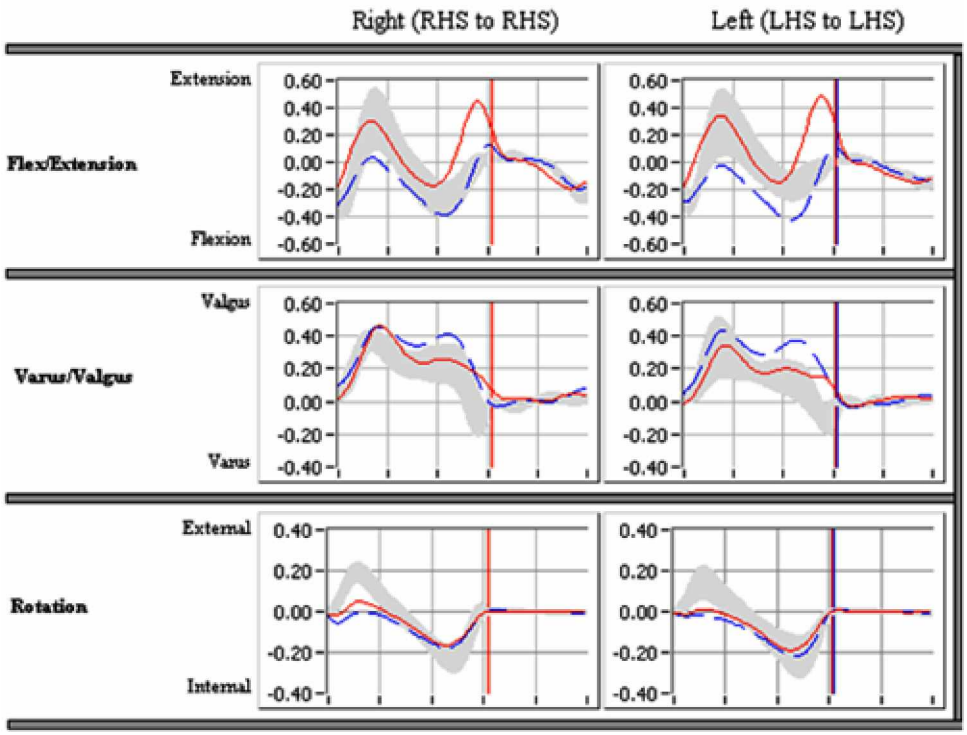

Figure C.62 Knee Joint Moments (Nm/Kg), 20-year-old subjects.

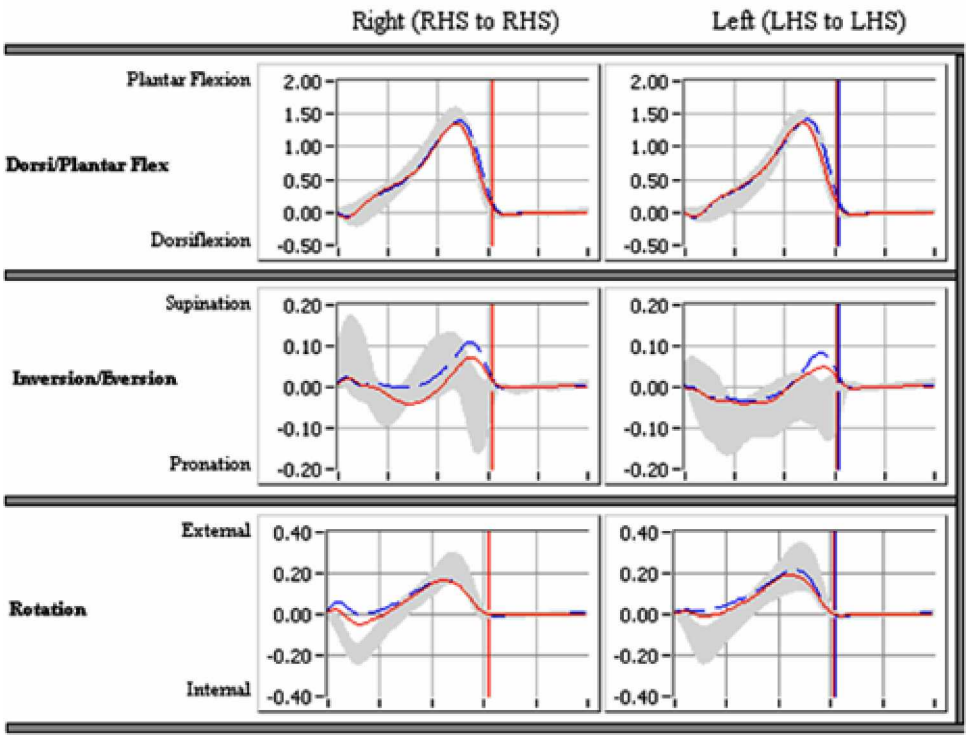

Figure C.63 Ankle Joint Moments (Nm/Kg), 20-year-old subjects.

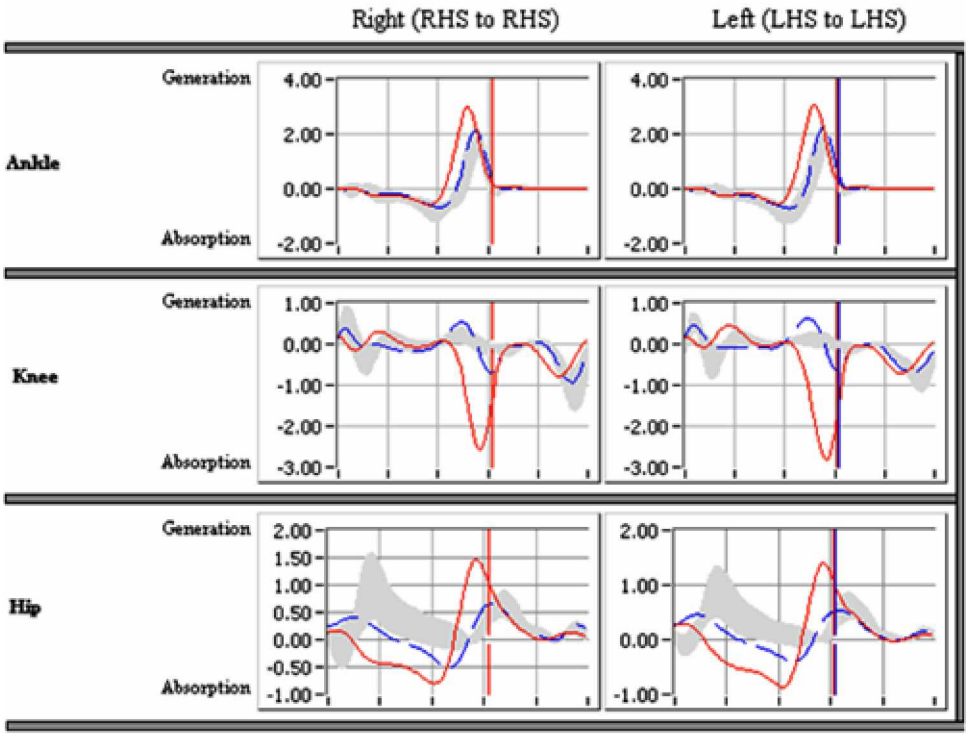

Figure C.64 Sagittal Joint Powers (Watts/Kg), 20-year-old subjects.

APPENDIX D

NINE-YEAR-OLD MALE TWINS

In the graphs,

- x-axis of the graphs represents 0-100% of the gait cycle,
- The gray bands represent norm data of Orthotrak software (Motion Analysis Corp.),
- RHS = Right Heel Strike and LHS = Left Heel Strike.

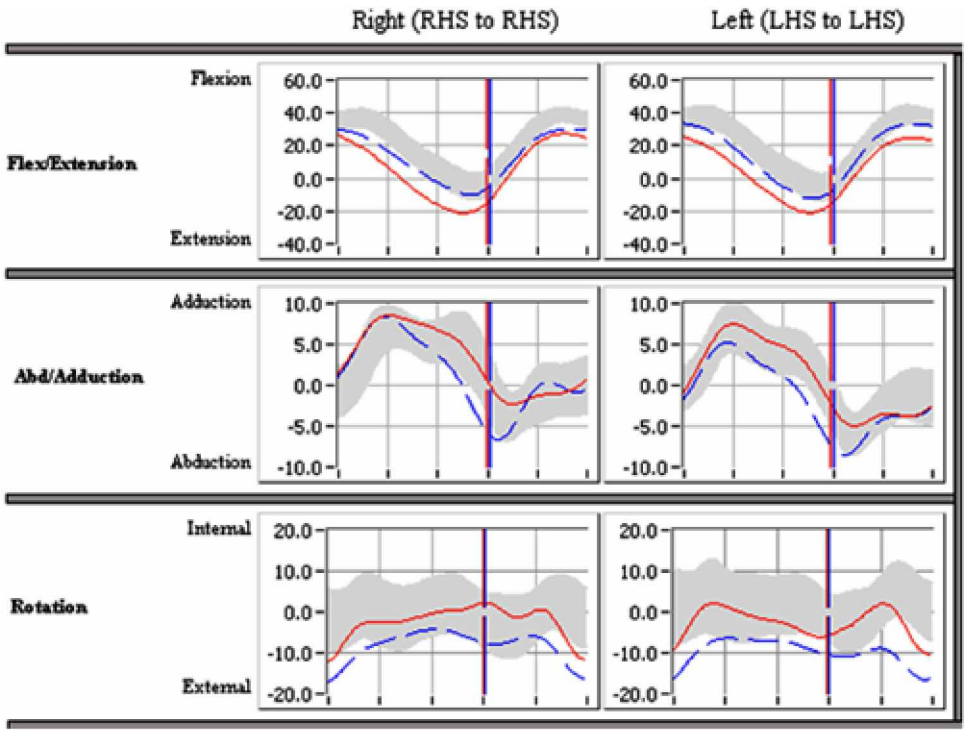

Figure D.1 Trunk Orientation Relative to Room (Degrees), 9-year-old male twins

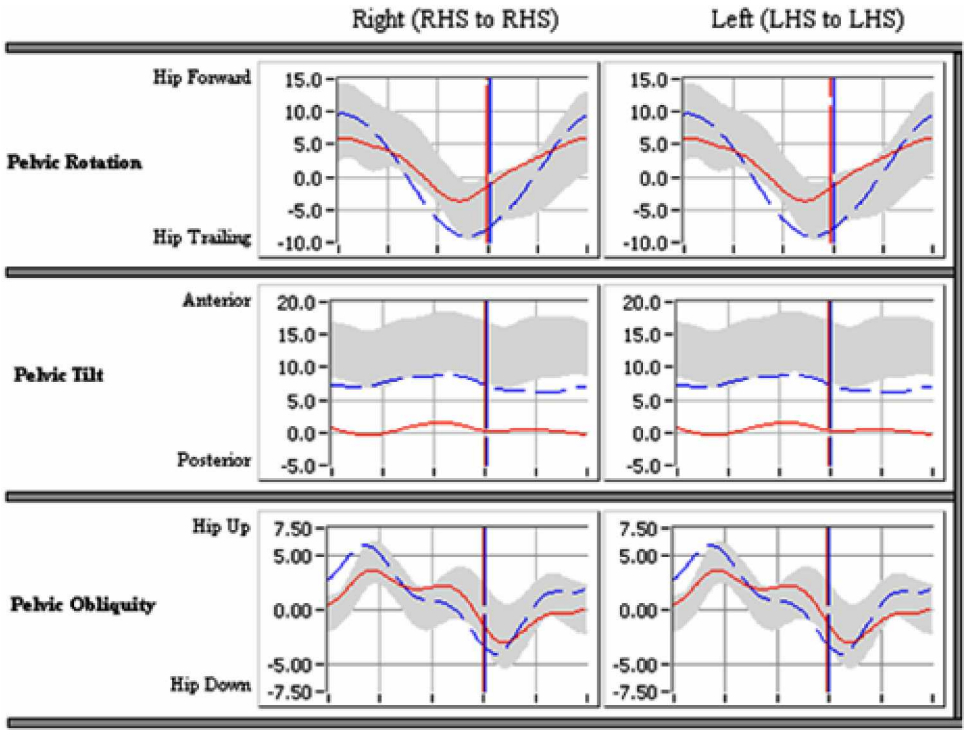

Figure D.2 Pelvic Orientation Relative to Room, 9-year-old male twins

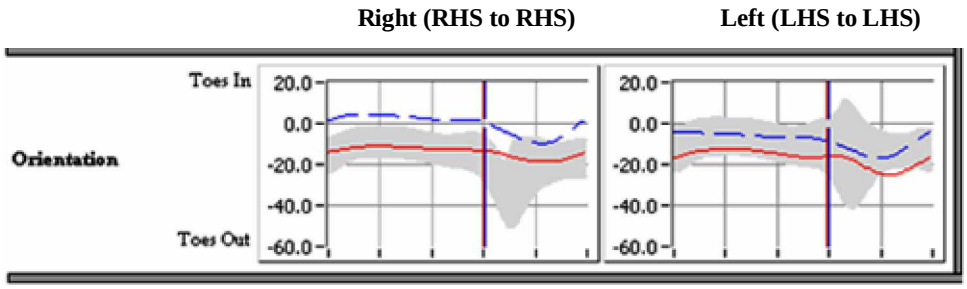

Figure D.3 Foot Orientation Relative to Room, 9-year-old male twins

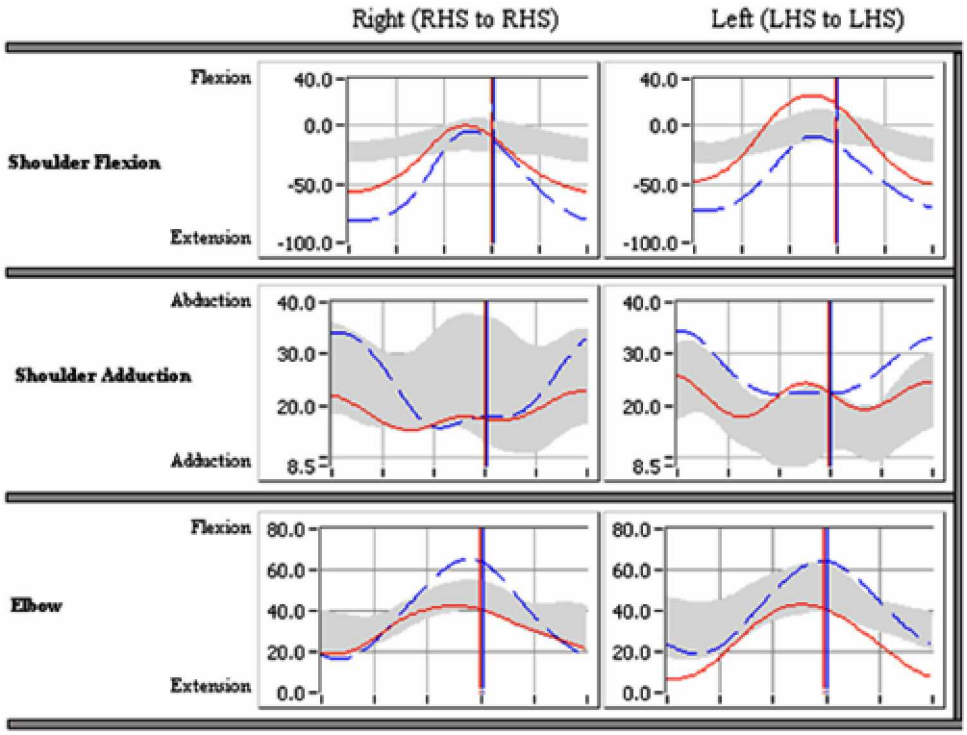

Figure D.4 Arm Joint Angles (Degrees), 9-year-old male twins

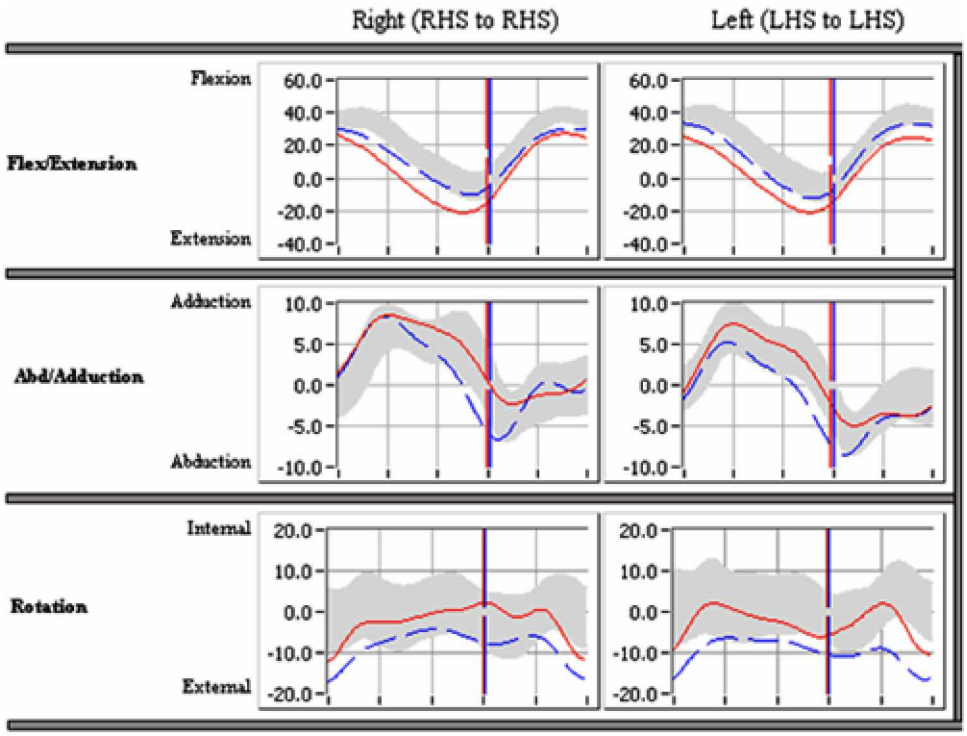

Figure D.5 Hip Joint Angles (Degrees), 9-year-old male twins

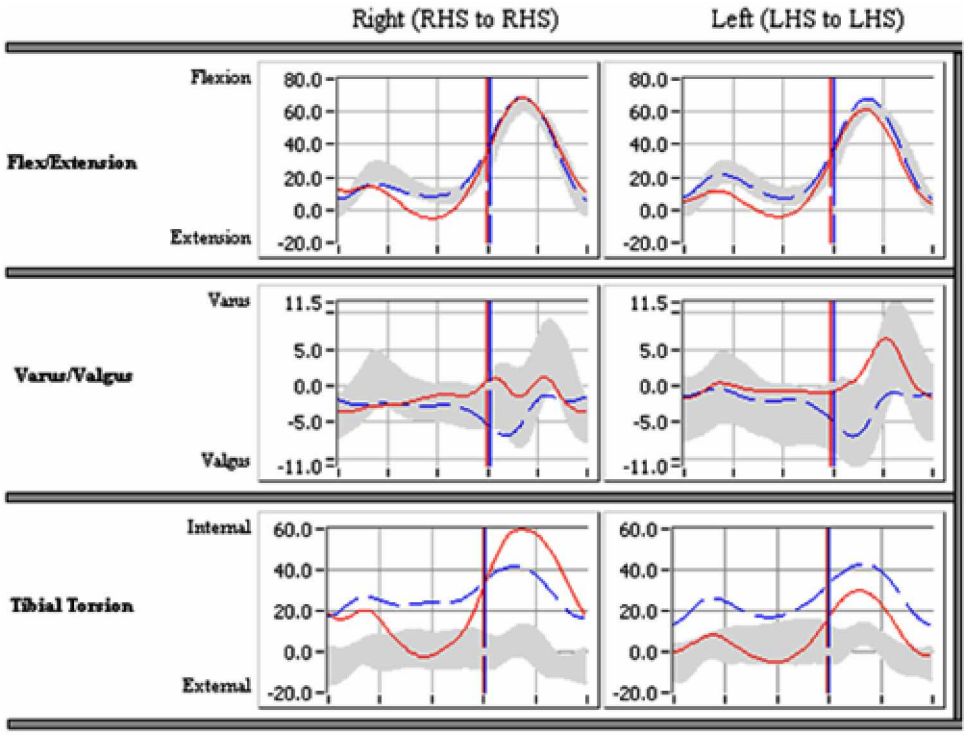

Figure D.6 Knee Joint Angles (Degrees), 9-year-old male twins

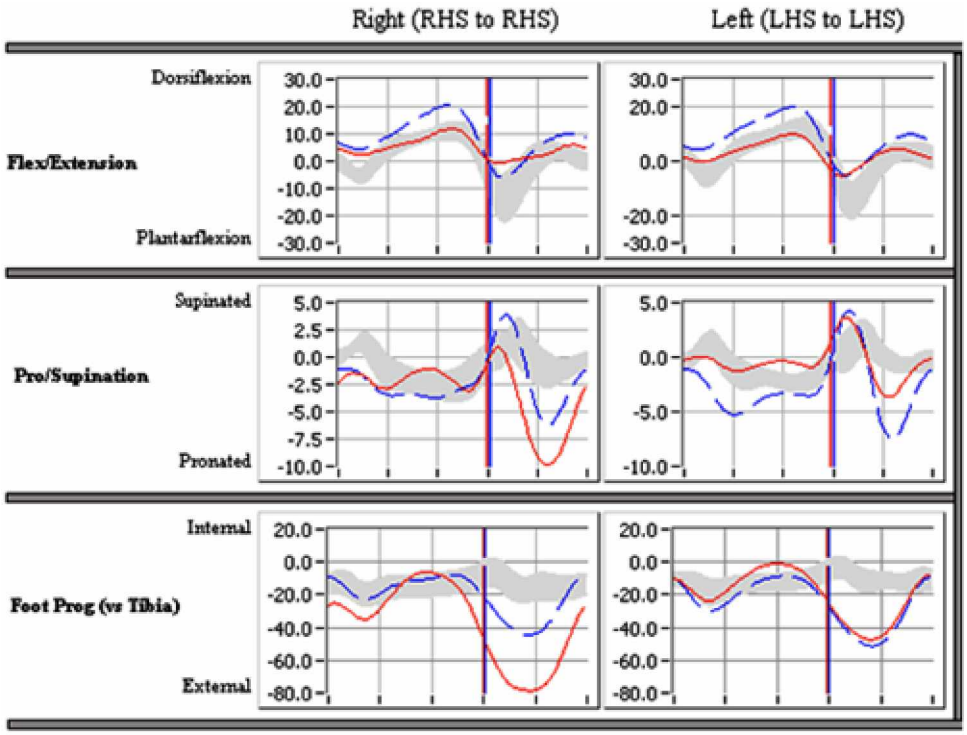

Figure D.7 Ankle Joint Angles (Degrees), 9-year-old male twins

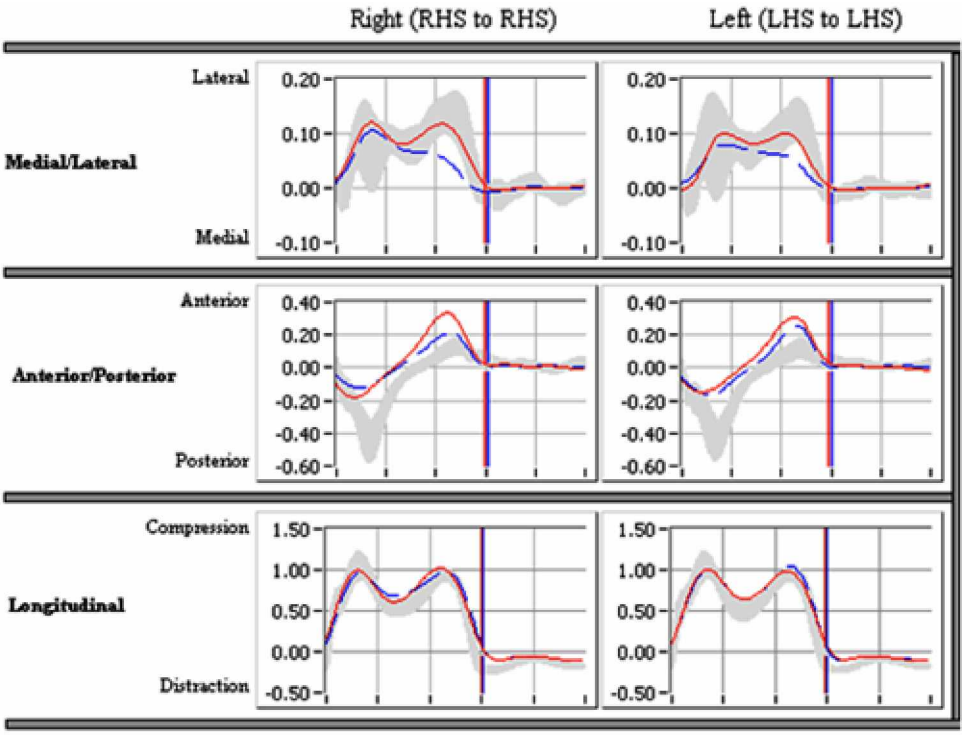

Figure D.8 Hip Joint Forces (N), 9-year-old male twins

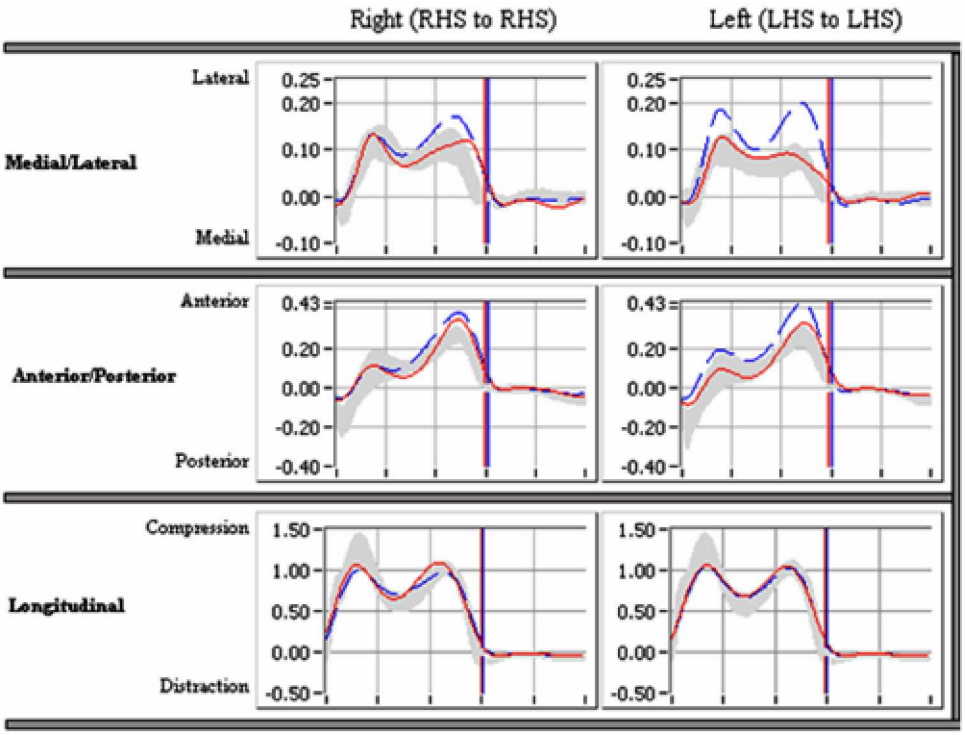

Figure D.9 Knee Joint Forces (N), 9-year-old male twins

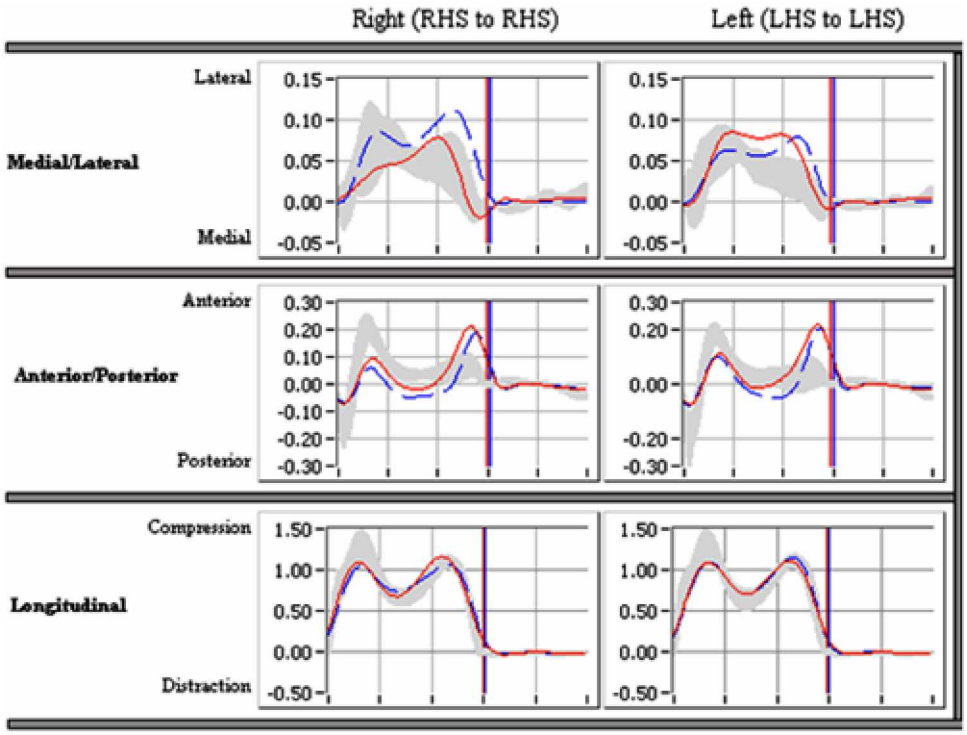

Figure D.10 Ankle Joint Forces (N), 9-year-old male twins

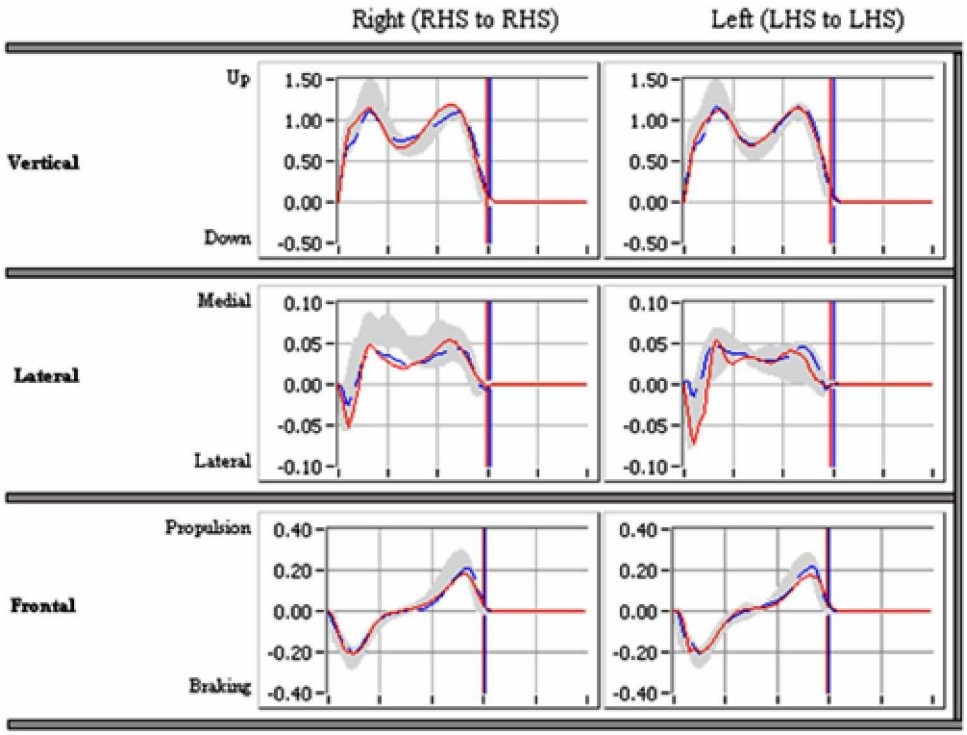

Figure D.11 Ground Reaction Forces (N), 9-year-old male twins

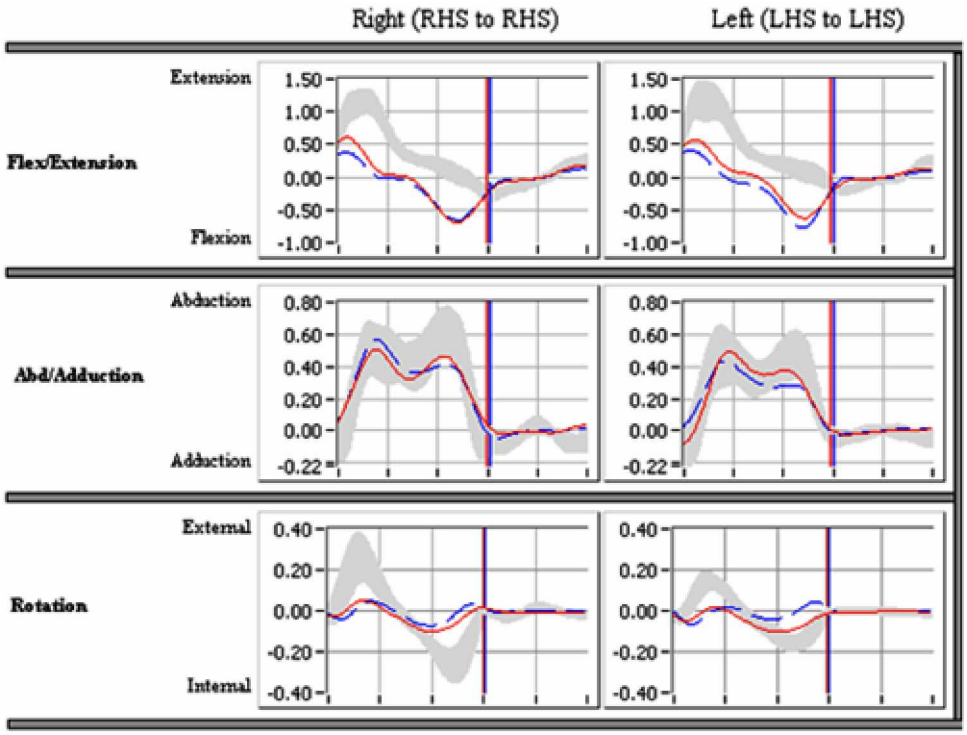

Figure D.12 Hip Joint Moments (Nm/Kg), 9-year-old male twins

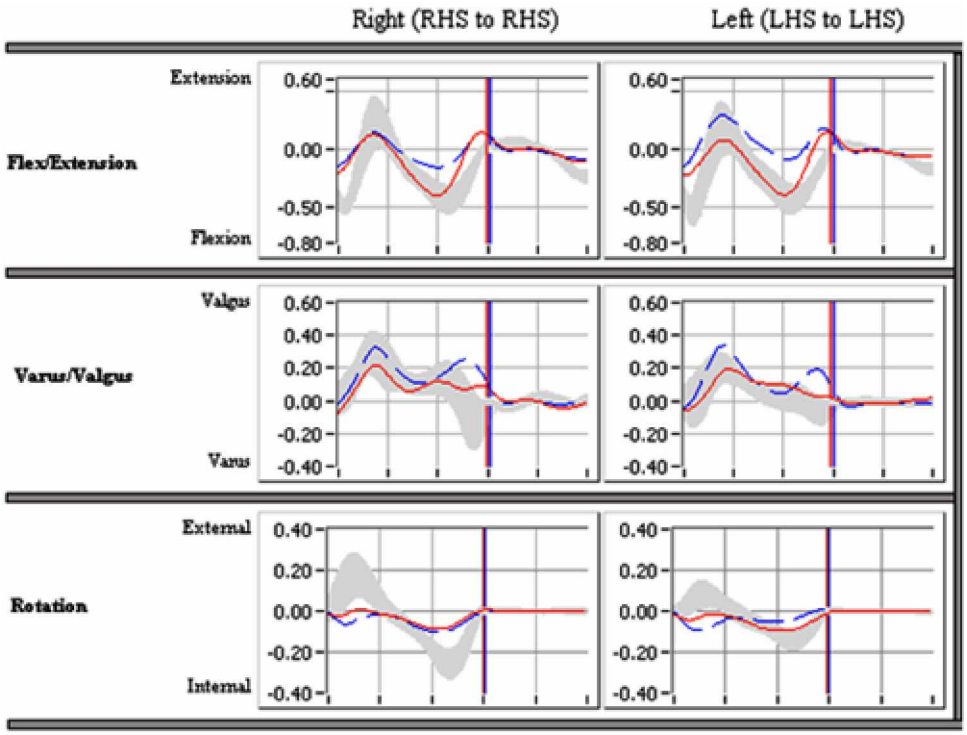

Figure D.13 Knee Joint Moments (Nm/Kg), 9-year-old male twins

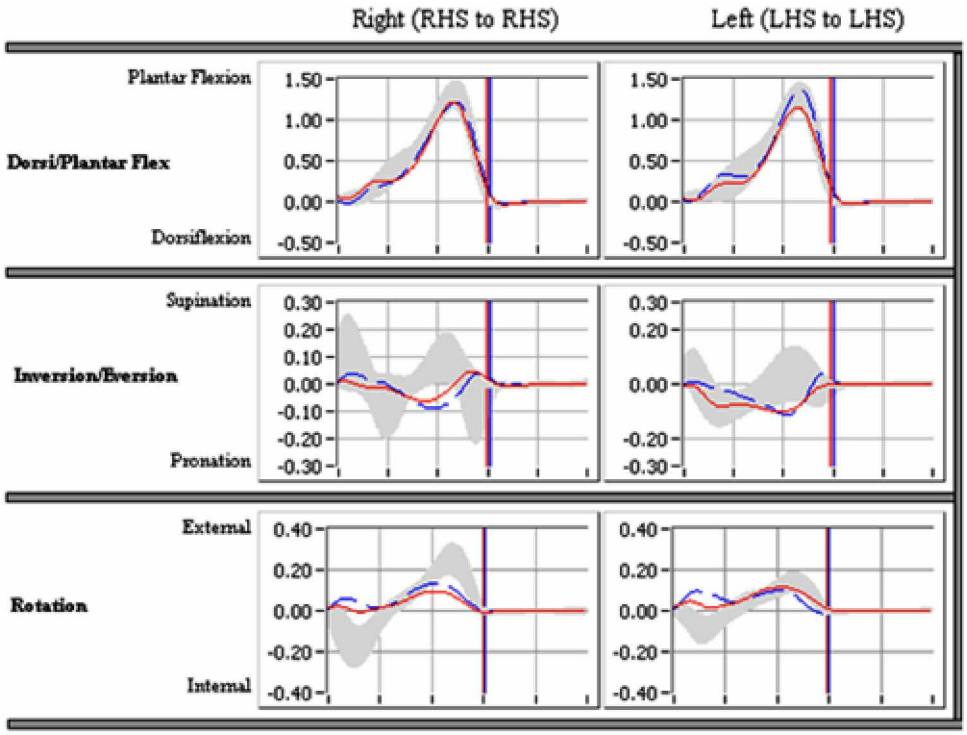

Figure D.14 Ankle Joint Moments (Nm/Kg), 9-year-old male twins

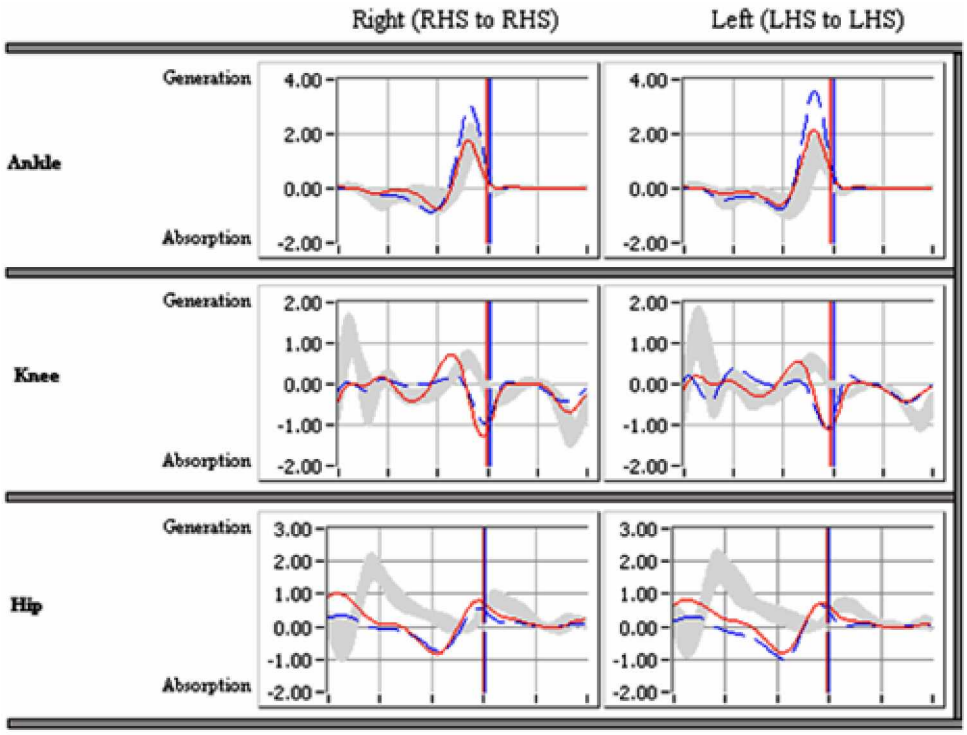

Figure D.15 Sagittal Joint Powers (Nm/Kg), 9-year-old male twins

APPENDIX E

STATISTICAL ANALYSIS

Sensitivity is defined as the proportion of all abnormal movements that are correctly defined as abnormal in the test. It is the number: (predicted abnormal and found abnormal)/ (found abnormal).

Specificity is defined as the proportion of all normal movements that are correctly defined as normal in the test. It is the number: (predicted normal and found normal)/ (found normal).

Positive Predictive Value is defined as the proportion of all abnormal movements tested that are predicted as abnormal by the test under evaluation. It is the number: (predicted abnormal and found abnormal)/ (predicted abnormal). As this value decreases, the probability of normal movements predicted as abnormal by the test under evaluation increases.

Negative Predictive Value is defined as the proportion of all normal movements tested that are predicted as normal by the test under evaluation. It is the number: (predicted normal and found normal)/ (predicted normal). As this value decreases, the probability of abnormal movements predicted as abnormal by the test under evaluation decreases.

In the following tables, TR stands for Turkish normative database, USA stands for the system's current normative database and 'Ref.' stands for the reference test. CP is the abbreviation of Cerebral Palsy, which a neuromuscular disease characterized by gait abnormalities.

Statistical Analysis for Hip Joint Movements:

Table E.1 h1: Flexion/Extension movements for right hip

REF.: TR

	CP	Normal	Total
Abnormal	9	1	10
Normal	1	19	20
Total	10	20	30

REF.: USA

	CP	Normal	Total
Abnormal	5	8	13
Normal	5	12	17
Total	10	20	30

Table E.2 h2: Abduction/Adduction movements for right hip

REF.: TR

	CP	Normal	Total
Abnormal	8	1	9
Normal	2	19	21
Total	10	20	30

REF.: USA

	CP	Normal	Total
Abnormal	9	10	19
Normal	1	10	11
Total	10	20	30

Table E.3 h3: Internal/External Rotation movements for right hip

REF.: TR

	CP	Normal	Total
Abnormal	5	2	7
Normal	5	18	23
Total	10	20	30

REF.: USA

	CP	Normal	Total
Abnormal	7	7	14
Normal	3	13	16
Total	10	20	30

Table E.4.h4: Flexion/Extension movements for left hip

REF.: TR

	CP	Normal	Total
Abnormal	6	1	7
Normal	4	19	23
Total	10	20	30

REF.: USA

	CP	Normal	Total
Abnormal	5	8	13
Normal	5	12	17
Total	10	20	30

Table E.5 h5: Abduction/Adduction movements for left hip

REF.: TR

	CP	Normal	Total
Abnormal	10	1	11
Normal	0	19	19
Total	10	20	30

REF.: USA

	CP	Normal	Total
Abnormal	8	4	12
Normal	2	16	18
Total	10	20	30

Table E.6 h.6: Internal/External Rotation movements for left hip

REF.: TR

	CP	Normal	Total
Abnormal	4	1	5
Normal	6	19	25
Total	10	20	30

REF.: USA

	CP	Normal	Total
Abnormal	9	10	19
Normal	1	10	11
Total	10	20	30

Table E.7 Sensitivity values, specificity values, positive predictive values (PPV) and negative predictive values (NPV) for hip movements.

	Sensitivity		**Specificity**		**PPV**		**NPV**	
Hip	**TR**	**USA**	**TR**	**USA**	**TR**	**USA**	**TR**	**USA**
h1	0.90	0.50	0.95	0.60	0.90	0.38	0.95	0.71
h2	0.80	0.90	0.95	0.50	0.89	0.47	0.90	0.91
h3	0.50	0.70	0.90	0.65	0.71	0.50	0.78	0.81
h4	0.60	0.50	0.95	0.60	0.86	0.38	0.83	0.71
h5	1.00	0.80	0.95	0.80	0.91	0.67	1.00	0.89
h6	0.40	0.90	0.95	0.50	0.80	0.47	0.76	0.91

Statistical Analysis for Knee Joint Movements:

Table E.8 k1: Flexion/Extension movements for right knee

REF.: TR

	CP	Normal	Total
Abnormal	9	0	9
Normal	1	20	21
Total	10	20	30

REF.: USA

	CP	Normal	Total
Abnormal	9	6	15
Normal	1	14	15
Total	10	20	30

Table E.9 k2: Varus/Valgus movements for right knee

REF.: TR

	CP	Normal	Total
Abnormal	6	1	7
Normal	4	19	23
Total	10	20	30

REF.: USA

	CP	Normal	Total
Abnormal	7	12	19
Normal	3	8	11
Total	10	20	30

Table E.10 k3: Internal/External Tibial Torsion movements for right knee

REF.: TR

	CP	Normal	Total
Abnormal	5	1	6
Normal	5	19	24
Total	10	20	30

REF.: USA

	CP	Normal	Total
Abnormal	9	19	28
Normal	1	1	2
Total	10	20	30

Table E.11 k4: Flexion/Extension movements for left knee

REF.: TR

	CP	Normal	Total
Abnormal	7	0	7
Normal	3	20	23
Total	10	20	30

REF.: USA

	CP	Normal	Total
Abnormal	7	11	18
Normal	3	9	12
Total	10	20	30

Table E.12 k5: Varus/Valgus movements for left knee

REF.: TR

	CP	Normal	Total
Abnormal	7	2	9
Normal	3	18	21
Total	10	20	30

REF.: USA

	CP	Normal	Total
Abnormal	7	12	19
Normal	3	8	11
Total	10	20	30

Table E.13 k6: Internal/External Tibial Torsion movements for left knee

REF.: TR

	CP	Normal	Total
Abnormal	4	2	6
Normal	6	18	24
Total	10	20	30

REF.: USA

	CP	Normal	Total
Abnormal	10	20	30
Normal	0	0	0
Total	10	20	30

Table E.14 Sensitivity values, specificity values, positive predictive values (PPV) and negative predictive values (NPV) for knee movements. Negative Predictive Value of the reference test USA for k6 is indeterminate (0/0), and it was accepted as 0.

	Sensitivity		**Specificity**		**PPV**		**NPV**	
Knee	**TR**	**USA**	**TR**	**USA**	**TR**	**USA**	**TR**	**USA**
k1	0.90	0.90	1.00	0.70	1.00	0.60	0.95	0.93
k2	0.60	0.70	0.95	0.40	0.86	0.37	0.83	0.73
k3	0.50	0.90	0.95	0.05	0.83	0.32	0.79	0.50
k4	0.70	0.70	1.00	0.45	1.00	0.39	0.87	0.75
k5	0.70	0.70	0.90	0.40	0.78	0.37	0.86	0.73
k6	0.40	1.00	0.90	0.00	0.67	0.33	0.75	0.00

Statistical Analysis for Ankle Joint Movements:

Table E.15 a1: Flexion/Extension movements for right ankle

REF.: TR

	CP	Normal	Total
Abnormal	9	1	10
Normal	1	19	20
Total	10	20	30

REF.: USA

	CP	Normal	Total
Abnormal	10	19	29
Normal	0	1	1
Total	10	20	30

Table E.16 a2: Pronation/Supination movements for right ankle

REF.: TR

	CP	Normal	Total
Abnormal	9	2	11
Normal	1	18	19
Total	10	20	30

REF.: USA

	CP	Normal	Total
Abnormal	10	20	30
Normal	0	0	0
Total	10	20	30

Table E.17 a3: Internal/External Foot Progression movements for right ankle

REF.: TR

	CP	Normal	Total
Abnormal	9	1	10
Normal	1	19	20
Total	10	20	30

REF.: USA

	CP	Normal	Total
Abnormal	10	20	30
Normal	0	0	0
Total	10	20	30

Table E.18 a4: Flexion/Extension movements for left ankle

REF.: TR

	CP	Normal	Total
Abnormal	7	2	9
Normal	3	18	21
Total	10	20	30

REF.: USA

	CP	Normal	Total
Abnormal	10	20	30
Normal	0	0	0
Total	10	20	30

Table E.19 a5: Pronation/Supination movements for left ankle

REF.: TR

	CP	Normal	Total
Abnormal	5	3	8
Normal	5	17	22
Total	10	20	30

REF.: USA

	CP	Normal	Total
Abnormal	10	20	30
Normal	0	0	0
Total	10	20	30

Table E.20 a6: Internal/External Foot Progression movements for left ankle

REF.: TR

	CP	Normal	Total
Abnormal	7	0	7
Normal	3	20	23
Total	10	20	30

REF.: USA

	CP	Normal	Total
Abnormal	10	20	30
Normal	0	0	0
Total	10	20	30

Table E.21 Sensitivity values, specificity values, positive predictive values (PPV) and negative predictive values (NPV) for ankle movements. Negative Predictive Values of the reference test USA for a2, a3, a4, a5 and a6 were indeterminate (0/0), and they were accepted as 0.

	Sensitivity		**Specificity**		**PPV**		**NPV**	
Ankle	**TR**	**USA**	**TR**	**USA**	**TR**	**USA**	**TR**	**USA**
a1	0.90	1.00	0.95	0.05	0.90	0.34	0.95	1.00
a2	0.90	1.00	0.90	0.00	0.82	0.33	0.95	0.00
a3	0.90	1.00	0.95	0.00	0.90	0.33	0.95	0.00
a4	0.70	1.00	0.90	0.00	0.78	0.33	0.86	0.00
a5	0.50	1.00	0.85	0.00	0.63	0.33	0.77	0.00
a6	0.70	1.00	1.00	0.00	1.00	0.33	0.87	0.00

Table E.22 Differences in mean, standard deviation (SD) and lower and range for gait parameters when the number of subjects was 10 or 12. All the subjects were 8-year-old females. % is the percentage of subjects falling outside the range when the number was 10. It can be stated that there was no statistically significant difference (Avg.: Average; R: Right; L: Left).

		Mean	SD	Mean–2SD	Mean+2SD	%
Avg. Step Width (cm)	**10**	8.38	2.06	4.26	12.5	
	12	8.18	1.93	4.32	12.04	
R_Velocity (cm/s)	**10**	113.05	13.65	85.75	140.35	
	12	112.44	12.43	87.58	137.30	
R_Stride Length (cm)	**10**	104.14	10.54	83.06	125.22	
	12	104.16	9.57	85.02	123.30	
R_Cadence (steps/min)	**10**	130.15	6.06	118.03	142.27	
	12	129.34	6.09	**117.16**	141.52	0.04
L_Velocity (cm/s)	**10**	114.06	13.77	86.52	141.60	
	12	113.41	12.61	88.19	138.63	
L_Stride Length (cm)	**10**	104.58	10.99	82.60	126.56	
	12	104.53	10.01	84.51	124.55	
L_Cadence (steps/min)	**10**	130.65	6.06	118.53	142.77	
	12	129.88	5.79	**118.30**	141.46	0.01
Right Toe Off (%)	**10**	61.21	0.91	59.39	63.03	
	12	61.14	1.03	**59.08**	**63.20**	0.08 and 0.04
Left Toe Off (%)	**10**	60.80	1.22	58.36	63.24	
	12	60.55	1.48	**57.59**	**63.51**	0.13 and 0.05

REFERENCES

1. Rose, J. and J.G. Gamble, *Human Walking Second Edition*, Baltimore: Williams & Wilkins, 1994.

2. Lorini, G., Bossi, D., Specchia, N., *The concept of movement prior to Giovanni Alfonso Borelli*, pp. 23, 1992.

3. Andriacchi, T.P., Alexander, E.J., "Studies of human locomotion: past, present and future," *Journal of Biomechanics*, Vol.33, pp. 1217-1224, 2000.

4. Dagg, A.I., "*Running, walking and jumping*," in Cappozzo, A., Marchetti, M., Tosi, V. (Eds.), *Biolocomotion: A Century of Research Using Moving Pictures*, pp. 19, Rome: Promograph, 1992.

5. Muybridge, E., "*Complete human and animal locomotion (All 781 Plates from the 1887 Animal Locomotion)*," in Cappozzo, A., Marchetti, M., Tosi, V. (Eds.), *Biolocomotion: A Century of Research Using Moving Pictures*, pp. 69, 1992.

6. Steindler, A. "A historical review of the studies and investigations made in relation to human gait", *Journal of Bone and Joint Surgery*, Vol. 35A, pp. 540-542, 1953.

7. Weber, W., Weber, E., "*Die Mechanik der menschlichen Gehwerkzeuge,"* in Cappozzo, A., Marchetti, M., Tosi, V. (Eds.), in Cappozzo, A., Marchetti, M., Tosi, V., *Biolocomotion: A Century of Research Using Moving Pictures*, pp. 126, Rome: Promograph, 1992.

8. Braune, W., Fischer, O., "*Determination of the moments of inertia of the human body and its limbs*," in Cappozzo, A., Marchetti, M., Tosi, V. (Eds.), *Biolocomotion: A Century of Research Using Moving Pictures*, pp. 125, Rome: Promograph, 1992.

9. Paul J.P., "Forces transmitted by joints in the human body," *Proc Inst Mech Eng*, Vol. 181, pp. 3J8-15, 1967.

10. Bresler, B. and Frankel, J., "The forces and moments in the leg during level walking," *Transactions of the ASME,* pp. 27-36., 1950.

11. Paul J. P., "Force actions transmitted by joints in the human body," *Proc Royal Soc*, Vol. 192, pp. 163-172, 1975.

12. Eng, J.J. and D.A. Winter, "Kinetic analysis of the lower limbs during walking: What information can be gained from a three-dimensional model?" *Journal of Biomechanics*, Vol. 28, pp. 753-758, 1995.

13. Winter, D.A., *Biomechanics and Motor Control of Human Movement, Second Edition*, pp. 75-100, John Wiley & Sons, New York, 1990.

14. Cappozzo A., "Gait analysis methodology," *Human Movement Science*, Vol. 3, pp. 27-50, 1984.

15. Eberhart, H. D., "Fundamental studies of human locomotion and other information relating to design of artificial limbs," *Subcontractors' Report to National Council*, Berkeley, California, 1947.

16. Inman, V. T., Ralston, H.J., Todd, F., Lieberman, J.C., *Human Walking*, Williams & Wilkins, Baltimore, London, 1981.

17. Benedetti, M. G., Cappozzo, A., "Anatomical landmark definition and identification in computer aided movement analysis in a rehabilitation context II" *Internal Report*, Universita Degli Studi La Sapienza, pp. 1-31, 1994.

18. Varadarajan S., "Motion Capture History and Pipeline," *Advanced Computing Center for the Arts and Design*, Ohio State University, in http://accad.osu.edu/~varadara/Class1.pdf, pp. 11-26, 2002.

19. Kirtley C., MD, PhD, *Introduction to Motion Analysis*, in http://www.polyu.edu.hk/cga.

20. Whittle M.W., *Gait analysis: an introduction Third Edition*, pp. 42-86, Oxford: Butterworth-Heinemann, 2002.

21. Fish, D.J., Nielsen J.P., "Clinical Assessment of Human Gait," *Journal of Prosthetics and Orthotics*, Vol. 5 (2), pp. 39-48, 1993.

22. Perry J., *Observational gait analysis handbook,* The Pathokinesiology Service and The Physical Therapy Department of Rancho Los Amigos Medical Center, California: The Professional Staff Association, pp. 27-46, 1989.

23. Perry J. "*Normal gait*". In Perry J., Schoneberger B (Eds.), *Gait analysis, normal and pathological function,* 1. ed., pp. 51-89, California: SLACK Inc., 1992.

24. Bontrager, E.L., "*Section Two Instrumented Gait Analysis Systems,*" in J.A. De Lisa, MD (Ed.), *Gait Analysis in the Science of Rehabilitation Monograph 002*, pp. 16-35, in http://www.vard.org/mono/gait/gaitcov.htm, 1998, last revised in 05/21/1999.

25. Perry, J., in *History of Study of Locomotion* in http://www.univie.ac.at/cga/history/modern.html.

26. Soutas-Little, R.W. Ph.D., "Section Two Chapter Two Motion Analysis and Biomechanics," in J.A. De Lisa, MD (Ed.), Gait Analysis in the Science of Rehabilitation Monograph 002, in http://www.vard.org/mono/gait/gaitcov.htm, 1998. Last revised in 05/24/1999.

27. Bronner, S., "*Instrumented Analysis of Human Movement"* in http://www.brooklyn.liu.edu/bbut04/adamcenter/Instrumented Analysis Website.

28. Ayyappa, E., "Normal Human Locomotion, Part 1: Basic Concepts and Terminology," *Journal of Prosthetics and Orthotics*, Vol. 9, Num. 1, pp. 10-17, 1997.

29. Murray, M.P., "Gait as a total pattern of movement," *American Journal of Physical Medicine,* Vol. 46(1), pp. 290-332, 1967.

30. Murray, M.P., Drought, A.B., Kory R.C., "Walking patterns of normal men", *Journal of Bone Joint Surgery*, Vol. 46-A (2), pp. 335-360, 1964.

31. Foster J.P., Nixon, M.S., Prugel-Bennett A., "New Area Based Metrics for Automatic Gait Recognition Department of Electronics and Computer Science," University of Southampton, in http://eprints.ecs.soton.ac.uk/8453/01/foster_bmvc2001.pdf, 2001.

32. Nixon, M. S. and Carter, J. N., “On Gait As A Biometric: Progress and Prospects,” in *Proceedings of Proc. EUSIPCO 2004*, Vienna, in http://eprints.ecs.soton.ac.uk/10101/01/nixon%5Feusipco04.pdf, 2004.

33. Al-Obaidi, S., Wall J.C., Al-Yaqoub A., Al-Ghanim M., “Basic gait parameters: A comparison of reference data for normal subjects 20 to 29 years of age from Kuwait and Scandinavia,” *Journal of Rehabilitation Research and Development*. Vol. 40, No. 4, pp. 361–366, July/August 2003.

34. Öberg, T., Karsznia, A., Öberg, K., “Basic gait parameters: Reference data for normal subjects, 10-79 years of age,” *Journal of Rehabilitation Research and Development*, Vol. 30 (2), pp. 210-223, 1993.

35. Jaskólski A., “Journal Reviews,” *Human Movement*, no. 1 (5), 2002, in http://www.awf.wroc.pl/hum_mov/english/05/index.htm.

36. Growney E., Meglan D., Johnson M., Cahalan T., An K., “Repeated measures of adult normal walking using a video tracking system,” *Gait & Posture*, Vol. 6 (2), pp. 147-162, October 1997.

37. Öberg, T., Karsznia, A., Öberg, K., “Joint angle parameters in gait: Reference data for normal subjects, 10-79 years of age,” *Journal of Rehabilitation Research and Development*, Vol. 31 (3), pp. 199-213, August 1994.

38. Lasko-McCarthey P., Beuter A., Biden E., “Kinematic variability and relationships characterizing the development of walking,” *Developmental Psychobiology*, Vol. 23 (8), pp. 809-837, December 1990.

39. Chao, E.Y., Laughman, R.K., Schneider, E., Stauffer, R.N, “Normative Data of Knee Joint Motion and Ground Reaction Forces in Adult Level Walking,” *Journal of Biomechanics*, Vol. 16, No. 3, pp. 219-233, 1983.

40. Zanchi V., Papić V., Cecić M., “Quantitative human gait analysis,” *Simulation Practice and Theory*, Vol. 8, pp. 127-139, 2000.

41. Pierrynowski M.R., Galea V., "Enhancing the ability of gait analyses to differentiate between groups: scaling gait data to body size," *Gait & Posture*, Vol. 13 (3), pp. 193-201, May 2001.

42. Yang, C., Chou, Y., Su, F., Lin, C., Chen, H., Giang, S., Chang, W., "Walking patterns of normal children aged from 4 to 6 years old and young adults in Taiwan," *Biomedical Engineering Applications, Basis Communications*, Vol. 8, No. 2, p 167-176, April 1996.

43. Kerrigan, D.C., Todd, M.K., Croce, U.D., "Gender differences in joint biomechanics during walking: Normative study in young adults," *American Journal of Physical Medicine & Rehabilitation*, Vol. 77, No. 1, pp. 2-7, 1998.

44. Sutherland D.H., Kaufman K.R., Campbell K., Ambrosini, D., Wyatt M., "Clinical use of prediction regions for motion analysis," *Developmental Medicine and Child Neurology*, Vol. 38 (9), pp. 773-81, 1996.

45. "Force Plates Data Acquisition Equipment" in http://physiotherapy.curtin.edu.au/home/facilities/equipment/force-plates.cfm, last modified 13 May 2004.

46. EVa 4.0 Reference Manual, Chapter 1: Overview, pp. 1-5, Motion Analysis Corporation, Santa Rosa, CA, USA, 2000.