

POSTURE AND
SPORTS PERFORMANCE

by

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ABSTRACT

The purpose of these investigations was to examine the influence of a device intended to “modify posture” and its influence on sports performance. We investigated the impact of a hand-grip device (e3 Fitness Grips, BioGrip, Sacramento, CA) designed to put the human skeleton in a “more favorable anatomical position,” on 3.2-kilometer (2-mile) running performance by measuring time and counting steps. We observed no change in running time but a significant change ($F(1,8)=5.7, p=0.04$) in step count, but only for participants who could run 3.2-kilometers (2-miles) under 14 minutes. If a person is able to run 3.2-kilometers under 14 minutes, then using the fitness grips may decrease the number of steps it takes to run a given distance, but may not improve time. In the second study, we evaluated the impact of an isometric exercise treatment with grips designed to put the human skeleton in a “more advantageous position” (e3 Swing Grips, BioGrip, Sacramento, CA) on bat speed. We observed that the grip exercise treatment significantly ($F(2,44)=7.6, p<.001$) increased mean bat speed immediately after doing the treatment by 33.4 ± 2.5 m/s (0.45 m/s) and after five minutes of rest by 34.0 ± 2.8 ms (0.9 m/s) for collegiate baseball players when compared with a triceps pushdown treatment (placebo post treatment 32.3 ± 2.3 and 5 min rest 33.2 ± 2.7 m/s) and no treatment (control post treatment 32.5 ± 3.1 and 5 min rest 33.2 ± 2.7 m/s), but not for softball players (grip treatment post 28.7 ± 1.5 and 5 min rest 28.9 ± 2.1 m/s). The ease in use of the postural grip treatment may be a practical way to incorporate intense isometric muscle contractions of the core musculature into practice or game conditions as a means of enhancing bat speed velocity in baseball players similar to those tested. A review of literature was conducted examining posture and sports

performance. The literature is clear that there are sport-specific postural deviations. It is unclear if these postural deviations lead to better performance or if a specific training plan should be developed to help build and maintain a more balanced body posture. Future research should examine the effect of posture control on static and dynamic movement.

LIST OF ABBREVIATIONS AND SYMBOLS

m/s	meters per second
PAR-Q	Physical Activity Readiness Questionnaire
s	seconds
SD	standard deviation
SPSS	Statistical Package for the Social Sciences
y	year
*	significant difference ($p < 0.05$)

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“Each one should use whatever gift he has received to serve others, faithfully administering God’s grace in its various forms. If anyone speaks, he should do it as speaking the very words of God. If anyone serves, he should do it with strength God provides, so that in all things God may be praised through Jesus Christ. To him be the glory and the power forever and ever. Amen.” – 1 Peter 4:10-11

There have been numerous people, each with different gifts and talents that have shared their time, knowledge, and wisdom with me along this journey. Many have given selflessly and have been a great example to others and me. These people, have left a path for me to follow, have shared truth in my life, and are the reason this dissertation has been completed. I want each of you to know that I am forever thankful to you for using your gift to serve, and because of you I praise God through Jesus Christ!

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CHAPTER 1

INTRODUCTION

Posture is influenced by heredity, disease, and habit (Wilford, 1996). Postural control and daily habits influence the way the body moves (Cook, 2003). The way a person controls their body during daily activities, as well as during sports participation, influences their posture.

Correct posture has been defined as a situation in which the center of gravity of each body segment is placed vertically above the segment below and creates a state in which muscular symmetry provides stability and guards the body against injury (Bloomfield, 1998; Watson, 2000; Britnell, 2005). This correct posture has been referenced to a vertical line passing through the external auditory meatus (ear), acromioclavicular joint of the shoulder, bodies of the lumbar vertebrae, greater trochanter of the hips, slightly anterior to the midline of the knee and lateral malleolus of the ankle, and through the calcaneocuboid joint (Kritz, 2008; Starkey, 2002; Kendall, 1993). Good posture helps optimize musculoskeletal health and performance (Bloomfield, 1998; Britnell, 2005; Hrysonmallis, 2001; Sahrmann, 2002; Watson, 2000). A body with correct posture will be in a state of equilibrium. Equilibrium is a state characterized by balanced forces and torques in which there is no wasted energy or unnecessary force production to accommodate body segments that are out of proper alignment (Bloomfield, 1998; Britnell, 2005; Hall, 2007). Correct posture allows for proper or optimal energy expenditure during static and dynamic activities (Kritz, 2008).

The focus of most posture research is related to health and productivity. Within sports, the biomechanical rationale for achieving and maintaining optimal posture is to move effectively, free of impairment and dysfunction (Kritz, 2008). This will allow an athlete to conserve energy and allow for maximal force production (Schexnayder, 2000).

In contrast, more muscular activity is required to maintain an abnormal or incorrect posture (Braun, 1991; Nordin, 2001). This increased activity may lead to pain and spasm (Calliet, 1991). Incorrect posture may also lead to the inhibition of the strained or lengthened muscle groups, furthering the complications of abnormal postural variations (Hunter, 1995; Cook, 2003). The antagonists of the strained, weak muscles often adaptively become shortened and strong (Kendall, 2005). Poor posture has also been noted to result in balance abnormalities, increased strain on supporting structures, such as the body's connective tissues, alterations in the quality of muscle function, changes in resting muscle length, and compromised organ function (Kendall, 2005; Hall, 1999; Sucher, 1990).

One of the most important, yet most neglected, variables in athletic performance is posture and proper positioning of the body (Schexnayder, 2000). Not only is posture important for performance, but athletic trainers and physical therapists have stressed the importance of posture and have often linked injuries to poor posture (Hennessy, 1993; Sahrman, 2002).

Posture habits are present and developed in every athletic event. This can be seen in many sporting activities: the way a batter stands in the batter's box, the way a tennis player prepares to serve, the way a golfer addresses the golf ball, and the way a shot putter sets herself in the ring. The postural control of the body has a lot to do with the way the body moves (Cook, 2003). The starting position, or the posture held at the beginning of any activity, influences the movement that is to follow (Cook, 2003). For example, an athlete who has abducted scapulae and rounded shoulder posture performing a pulling movement may need to first adduct and medially rotate the scapulae to be in the correct postural position to perform a technically proficient pulling movement (Kritz, 2008). Anticipatory strategies such as the example given are less efficacious, causing the athlete to waste energy to perform a safe and technically proficient

movement pattern (Kritz, 2008). Improper posture in sports often causes instability and may harm technique as well as lead to compensatory movement patterns (Schexnayder, 2000). Poor posture can also cause the arms and legs to operate incorrectly and inefficiently, since muscle recruitment patterns are effected (Schexnayder, 2000).

In contrast, proper posture enhances performance by maximizing force production and improving technique (Schexnayder, 2000). In most athletic events, the application of force is of critical importance and proper posture is a prerequisite to maximal force production (Schexnayder, 2000).

Because posture may influence force production and muscle recruitment patterns, the first study set out to investigate the influence of hand position change on running performance. This study investigated the impact of a hand-grip device (e3 Fitness Grips, BioGrip, Sacramento, CA) designed to put the human skeleton in a “more favorable anatomical position,” on 3.2-kilometer (2-mile) running performance by measuring time and counting steps. The second study examined the effects of an isometric postural exercise on bat speed. The purpose of this study was to evaluate the impact of an isometric exercise treatment with grips designed to put the human skeleton in a “more advantageous position” (e3 Swing Grips, BioGrip, Sacramento, CA) on bat speed. The third study is a review of literature examining posture and sports performance.

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CHAPTER 2

INFLUENCE OF A HAND POSITION CHANGE ON RUNNING PERFORMANCE

ABSTRACT

A single-blind, placebo-controlled, repeated-measures, counter-balanced, study was conducted which investigated the impact of a hand-grip device designed to put the human skeleton in a “more favorable anatomical position,” on 3.2-kilometer (2-mile) running performance by measuring time and counting steps. Thirty-seven healthy volunteers (age 21 ± 1.6 years, weight 75.1 ± 12.0 kg, height 174.8 ± 9.0 cm, 31 males, 6 females) completed the experimental protocol. Each participant ran 3.2 kilometers on three different occasions with one of three different treatments. Treatments included manufacturer’s recommended use of the fitness grips (experimental treatment), holding the fitness grips upside down (placebo treatment), and the use of no grips (control treatment) while running 3.2-kilometers. Time to the nearest 0.1 second was recorded and the steps for each participant were counted for 36.6 meters of every lap (10 laps total). The recorded times and step counts were analyzed with a repeated-measures ANOVA to determine if there were any differences in group means. There were no significant differences among trials ($p=0.9$) for run time in seconds. There were also no significant differences ($p=0.3$) for step count. However, when the participants were grouped by run time, the proper use of the fitness grips (experimental treatment) revealed a significantly ($p<0.05$) lower step count than that of the upside down grip (placebo) and the no grips (control). In the present study, we observed no change in running time performance and only a significant change in step count for participants who could run 3.2-kilometers (2-miles) under 14 minutes. If a participant is able to run 3.2-kilometers under 14 minutes, then using the fitness grips may decrease the number of steps it takes to run a given distance, but may not improve time.

Key Words: run biomechanics, stride length, anatomical position, run time

INTRODUCTION

Researchers have conducted numerous studies to determine which variables are associated with running performance and efficiency. These variables include: biomechanics (Dixon, SJ 2003), age (Daniels, 1978), gender (Bransford, 1977), body mass (Bergh, 1991), body fat (Crawford, 2011), maximal aerobic power (Mayhew, 1977), muscle fiber distribution (Bosco, 1987), and resistance training (Kraemer, 2004). It is clear that running is a complex skill that involves many variables which enhance or impede performance. Any change in running mechanics that results in a runner using less energy at any given speed is advantageous to performance (Cavanagh, 1982).

Biomechanical studies of elite long distance runners have attempted to identify how body structure and running mechanics affect performance. Although moderate relationships have been identified, there are conflicting results, and easily identifiable and applicable patterns of efficient or proper movement have not been established (Williams, 2007). Although there are not easily identifiable patterns of efficient movement, Saunders et al. (2004) have identified factors affecting running economy (Table 1). Among these factors, elite and good runners are more symmetrical, have better running economy (Cavanagh, 1977), and tend to exhibit less arm movement (Williams, 1987). Anderson has identified biomechanical factors related to running economy (Figure 1) (Anderson, 1996).

Although Anderson (1996) noted that reduced arm motion and faster rotation of shoulders in the transverse plane is advantageous, no research has investigated the possibility of creating a more stable hand and shoulder to increase running performance. Research shows that

no single variable or subset of variables can explain individual differences in running economy, but the weighted sum of several variables or subsets will influence running performance and/or economy (Williams, 1987). Hand and shoulder stability may be variables that may influence running performance.

This study aimed to evaluate the impact of a hand-grip device designed to put the human skeleton in a “more favorable anatomical position” (e3 Fitness Grips, BioGrip, Sacramento, CA), on 3.2-kilometer (2-mile) running performance. The hand grips were developed to put the hands in an anatomically neutral position allowing the shoulder girdle to be in “correct alignment” and allow for better posture. The advantages of having good posture may impact both mechanical function and economy. When the vertical line of gravity falls through the supporting column of bones and body structures, the runner does not have to continually adjust to counteract the forces of gravity (Bloomfield, 1998; Britnell, 2005). Logically, if the body is in better alignment or posture, then the body may use energy more economically.

Economy in endurance running could present itself in the ability to run a given distance in less time, or the ability to do less work (take fewer steps per given distance), or both. For this reason, the main purpose of this study was to investigate the impact of a hand-grip device designed to put the human skeleton in a “more favorable anatomical position” (e3 Fitness Grips, BioGrip, Sacramento, CA), on 3.2-kilometer (2-mile) running performance by measuring time and by counting steps.

METHODS

Experimental Approach to the Problem

This study used a single-blind, placebo-controlled, repeated-measures, counter-balanced, design to measure 3.2-kilometer (2-mile) run performance while holding the fitness grips

(experimental treatment). Participants also ran while holding the fitness grips upside down (placebo treatment), and with no grips (control treatment). Time to the nearest 0.1 second was recorded as the dependent variable. The number of steps were counted for 36.6-meters of each lap around an indoor track (10-laps = 3.2-kilometers). The participants were filmed by a video camera along 36.6 meter section of the track to effectively count the selected participant's steps during each of the treatments. Steps were counted as a simple method of assessing whether there was a significant change in biomechanics. We hypothesized, based on pilot data, that run performance would be changed. Slow motion blinded video records were used to assess any change in step count (stride length) of the participants' running.

Participants

At the beginning of the study, 61 participants were recruited and volunteered through the University Reserve Officers' Training Corps (ROTC). Participants were introduced to study procedures prior to agreeing to volunteer and signing an informed consent. The exclusion criterion included any physical condition that put the participant at risk for injury. This included, but was not limited to: heart or cardiovascular problems, knee, foot or ankle injuries, any stress fracture, etc. Safety was the key concern; therefore, the volunteers were required to be in excellent health. However, this research procedure did not exceed the physical demands that participants typically encountered during their training for the Army ROTC. The 3.2-kilometer (2-mile) run was and is part of Army ROTC training and testing.

Testing procedures and risks were fully explained, and participants were asked to provide written informed consent in accordance with the local Institutional Review Board. Any participants who ROTC officers did not approve to participate were excluded from the study. A

Physical Activity Readiness Questionnaire was also used to ensure that the participants were healthy enough to perform the study.

37 healthy participants (age 21 ± 2 years, weight 75.1 ± 12.0 kg, height 174.8 ± 9.0 cm, 31 males, 6 females) completed the experimental protocol. The participants who volunteered but did not complete all of the testing protocol were not used in the analysis of this study. Although the drop-out was large, it was beneficial to the study because the motivation of the participants who did not complete each protocol was in question, and may have confounded the results of this study.

During the first testing session, there were 21 participants who were randomly selected to have their steps counted for 36.6-meters for every lap (10 laps) around the track, to assess any change in run biomechanics. Of the 21 who were randomly selected, 16 completed the experimental protocol.

Experimental Procedures

A single-blind, placebo-controlled, repeated-measures, counter-balanced design was used to measure 3.2-kilometer (2-mile) run performance for each of the treatments. Each participant received all treatments. Treatments included holding the fitness grips (experimental treatment), holding the fitness grips upside down (placebo treatment), and no grips (control treatment). Time to the nearest 0.1 second and steps were recorded as the dependent variables. Testing was completed at the climate-controlled University indoor training facility. Ten laps around the indoor track equaled 3.2-kilometers (2-miles).

Prior to each testing session, a standardized and consistent warm-up was conducted by ROTC. During the first testing session, individuals were randomly assigned to a treatment. One third of the participants ran two miles without grips (control), one-third of the participants held

the fitness grips upside down (placebo), and one-third of the participants held the fitness grips correctly (experimental). During the second testing session, the participants who ran without fitness grips held the grips upside down, the participants who held the fitness grips upside down held them correctly, and the participants who held the fitness grips ran with no grips. During the third testing session, each participant received the treatment they had not previously received. Table 2 shows the design of the testing sessions.

During the first testing session, 21 participants were randomly selected to have their steps counted for 36.6 meters for every lap (10 laps) around the track (seven participants from the no-grips treatment (control), seven participants from the upside down grips treatment (placebo), and seven participants from the fitness grips treatment(experimental)). Only 16 participants with the steps counted completed all treatments.

To insure that steps were counted correctly, two camcorders were set up to capture the 36.6 meters. Each participant was assigned a number that was placed on his/her back. This numbering system allowed discarding any identifiers during video recording and allowed accurate identification of participants while counting steps. The track was marked so that “step count zone” could be seen during video recording. The counter was blinded to the treatment condition.

All groups were instructed on how to hold the grips correctly or upside down, though they were not advised regarding the role of the grips. Each person’s laps and their 3.2-kilometer (2-mile) performance time were recorded.

Statistical Analyses

The statistical analyses were performed using SPSS 19 (SPSS, Inc., Chicago, Illinois). The mean timed 3.2-kilometer run data and step data were analyzed with a repeated-measures

analysis of variance to determine if there was any difference in treatment means. LSD post hoc tests were used to evaluate any differences between treatments. All data are presented as means \pm SD.

RESULTS

Treatment was given in three different sequences for the counter-balanced design. The treatment order effect was non-significant ($F = 1.017$, $p = .37$). Therefore the counter-balanced design was effective in controlling for any treatment order effect in the study.

There were no significant mean differences ($F(2,72)=.11$, $p=0.9$) between treatments for time run in seconds, even when participants were divided into different groups based on time to complete the run (under 14 min, between 14-16 min, and 16-18 min). Participants were classified by having two or more run times within those time groups. Table 3 is a comparison of treatments for 3.2-kilometer run performance in seconds.

There were no significant differences $F(1,15)=.94$, $p=0.3$ for step count for all participants. There was a significant difference $F(1,8)=5.72$, $p=0.04$ in step count data for participants who ran under 14 min ($n=9$). The grips treatment resulted in a significantly lower step count for the grips compared to the placebo (upside down) and to the control (no grips). Table 4 is a comparison of 36.6-m (sum 10-laps) 3.2-kilometer step count data.

Discussion

In this study we observed that the grips did not impact running performance time in a single-use protocol. However, the grips did make a significant difference ($p<0.05$) in step count for participants who could run under 14 min for 3.2-kilometers compared to the upside down

position (placebo group) and to the no grips (control group). A decrease in step count would mean an increase in stride length, which did not translate into a faster time.

A limitation of this study was that we only counted a small portion of the steps (approximately 12.5%) of the total distance run. There may have been a much more pronounced variation in step count if all steps were counted; however this did not impact run time.

Counting steps or strides is something that is used in athletic venues. Hogberg (1952), at the Olympics in Stockholm, counted strides of elite distance runners from each lap and from there calculated stride length. He determined that the stride length of elite distance runners varied based on the distance and speed of the race (Hogberg, 1952). Research has shown that the most economical running comes from a self chosen stride length (Cavanagh, 1982; Hogberg 1952). An increase or decrease in stride length from a freely chosen one, generally results in an increase in O₂-consumption (Cavanagh, 1982; Hogberg 1952). In our study we witnessed an increase in stride length measured by step count, but running time to completion was unchanged. Obviously there were other unmeasured compensations besides stride length.

One of the limitations of this study was that we used non-elite runners. It is quite clear that participants trained in endurance running are more economical than their untrained counterparts (Hogberg, 1952; Bransford, 1977; Leskinen, 2009). Since running is related to a weighted sum of the influences of many variables (Williams, 1987), it may have been more advantageous to investigate use of the grips on elite runners since they may be more sensitive to changes in their running technique. Testing elite runners has the possibility of eliminating confounding variables.

PRACTICAL APPLICATIONS

In the present study we observed no change in running time performance and a significantly lower step count only for participants who could run 3.2-kilometers (2-miles) under 14 minutes. If a participant is able to run 3.2 kilometers under 14 minutes, then using the fitness grips may decrease the number of steps it takes to run a given distance, but may not improve time.

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TABLES AND FIGURES

Table 1. Factors affecting running economy (Saunders, 2004).

Performance in Distance Runners – Running Economy				
Training	Environment	Physiology	Biomechanics	Anthropometry
<ul style="list-style-type: none"> • Plyometrics • Resistance • Training Phase • Speed, volume, intervals, hills, etc. • Sleep • Food intake 	<ul style="list-style-type: none"> • Altitude • Heat • Cold • Wind • Running terrain 	<ul style="list-style-type: none"> • Maximal oxygen uptake (VO₂ Max) • Adolescent development • Metabolic factors • Influence of different running speeds 	<ul style="list-style-type: none"> • Flexibility • Stored elastic energy • Mechanical factors • Ground reaction force 	<ul style="list-style-type: none"> • Limb morphology • Muscle stiffness, tendon length • Bodyweight and composition

Body Type	Biomechanics	Training & Other
<ul style="list-style-type: none"> • Height- males are average or slightly smaller, females are slightly greater than average females • Ectomorphic or mesomorphic physique • Low percentage of body fat • Narrow pelvis • Smaller than average feet 	<ul style="list-style-type: none"> • Stride length - freely chosen over considerable training time • Low vertical oscillation of center of body mass • More acute knee angles during swing • Less range of motion but greater angular velocity of plantar flexion during toe-off • Not excessive arm motion • Faster rotation of shoulders in transverse plane • Greater angular excursion of the hips and shoulders about the polar axis in the transverse plane • Low peak ground reaction time • Effective use of stored elastic energy 	<ul style="list-style-type: none"> • Comprehensive training background • Shoes are lightweight but well cushioned • Running surface is intermediate compliance

Figure 1

Table 2. Design of Testing Sessions

1 st Testing Session	2 nd Testing Session	3 rd Testing Session
A – no grips B – upside down grips C – fitness grips	C – fitness grips A – no grips B – upside down grips	B – upside down grips C – fitness grips A – no grips
21 participants randomly selected to have strides counted for 36.6-meters every lap (10-laps equals 2-miles)	Same 21 participants selected to have strides counted for 36.6-meters every lap (10-laps equals 2-miles)	Same 21 participants selected to have strides counted for 36.6-meters every lap (10-laps equals 2-miles)

Table 3. Comparison of Treatments for 3.2-kilometer Run Performance (sec)

	All participants n=37	Participants under 14 min (n=13)	Participants from 14-16 min (n=13)	Participants from 16-18 min (n=9)
	Time (sec) Means \pm SD	Time (sec) Means \pm SD	Time (sec) Means \pm SD	Time (sec) Means \pm SD
No Grip (control)	934 \pm 120	822 \pm 44	891 \pm 42	1019 \pm 36
Upside down (placebo)	930 \pm 119	818 \pm 45	902 \pm 42	1026 \pm 43
Fitness Grips	934 \pm 113	819 \pm 35	905 \pm 36	1045 \pm 47

Table 4. Comparison of 36.6 m (sum 10-laps) Step Count Data during 3.2-kilometer run.

	Participants under 14 min (n=9)	Participants under 16 min (n=12)	All participants n=16
	Number of Steps Means \pm SD	Number of Steps Means \pm SD	Number of Steps Means \pm SD
No Grip (control)	252 \pm 15	257 \pm 17	277 \pm 39
Upside down (placebo)	254 \pm 14	257 \pm 12	281 \pm 43
Fitness Grips	242 \pm 9*	249 \pm 14	274 \pm 43

*Significant ($p < 0.05$) fewer steps compared to placebo and control

FIGURE CAPTIONS

Figure 1. Biomechanical factors related to better economy in runners (Anderson, 1996).

CHAPTER 3

IMPACT OF AN ISOMETRIC POSTURAL EXERCISE ON BAT SPEED

ABSTRACT

A single-blind, placebo-controlled, repeated-measures, counter-balanced, study was designed to measure bat swing speed. Participants were competitive collegiate NCAA Division I baseball and softball players who were well trained in swinging a bat. Sixteen male baseball players (age 20.1 ± 0.9 years, weight 84.9 ± 8.7 kg, height 182.1 ± 6.3 cm) and 12 female softball players (age 20.1 ± 1.0 years, weight 72.2 ± 14.5 kg, height 169.1 ± 8.6 cm) took part. Each participant swung their bat as fast as possible on three different occasions with each of three different treatments. Each participant had five minutes to perform a consistent warm-up. After warming up, each participant performed three swings with the bat speed of each swing recorded. Then, each participant, in a randomly assigned, counterbalanced order, to no exercise (control treatment), a triceps pushdown with a rope grip (placebo treatment), or a grip exercise (experimental treatment) followed by seven swings with the bat. Bat speed of each swing was recorded. Following their swings, each participant rested for five minutes and repeated their seven swings. The slowest and fastest swings for each participant were discarded and the other five swings for each condition were averaged. Bat speeds were analyzed with a repeated-measures ANOVA. We observed that the grip exercise treatment significantly ($F(2,44)=7.6$, $p<.001$) increased mean bat speed immediately after performing the treatment 0.45 m/s (1 mph) (33.4 m/s ± 2.5) and after five minutes of rest by 0.9 m/s (2 mph) (34.0 ± 2.8) for collegiate baseball players when compared with a triceps pushdown treatment (placebo post treatment 32.3 ± 2.3 and after 5 min rest 33.2 ± 2.7) and no treatment (control post treatment 32.5 ± 3.1 and after 5 min rest 33.3 ± 2.7 m/s), but not for softball players. The ease in use of the postural grip

treatment may be a practical way to incorporate intense isometric muscle contractions of the core musculature into practice or game conditions as a means of enhancing bat speed velocity.

Keywords: anatomical position, potentiation, swing velocity, core, motor recruitment

INTRODUCTION

According to previous research, one way in which a baseball or softball player can become a successful hitter is to improve his/her bat swing speed (Breen 1967; DeRenne 2007; Hay 1985; Polk, 1978). There are three direct benefits of increasing bat velocity. They include: an increased decision-making time by the batter (Szymanski, 2009), decreased swing time (assuming swing mechanics have not changed) (Hay, 1985; Polk, 1978), and an increased batted-ball velocity (Adair, 2002; Race, 1961). Increased bat speed can give the batter more time to make a decision and make contact with a pitch. The amount of time a batter has to evaluate a thrown pitch and decide whether to swing is referred to as decision-making time (Hay, 1985). In professional baseball, decision-making time lasts between 0.26 and 0.35 seconds and enhanced bat speed can allow the batter more decision making time (Breen, 1967).

Increased bat speed leads to increased energy delivered to the ball. An example of increased batted-ball velocity is shown in the following scenario. If a baseball was thrown at 38 m/s (85 mph) and was hit by a baseball player whose bat speed was 31.3 m/s (70 mph), then the ball would travel 114 m (~375 ft). If that same 38 m/s (85 mph) baseball was thrown and the hitter's bat speed was 33.5 m/s (75 mph), then the ball would travel 125 m (~410 ft) (assuming all other conditions equal).

Since the first scientific research in 1967 on the importance of bat speed, very little has changed about the game of baseball and softball, but the methods of training have changed

dramatically (Breen 1967; Szymanski, 2009). The effect of the weight of a bat swung in the on-deck circle and bat velocity has been investigated (DeRenne, 1982; DeRenne, 1986; DeRenne, 1992; Montoya, 2008; Southard, 2003).

Research suggests that a high school or collegiate baseball player should warm up with a specific, weighted bat that is nearly identical or very close to the same weight ($\pm 12\%$) as their standard game bat, and they should swing in a manner that mimics game velocity (Szymanski, 2009). In contrast, swinging a bat that is very light ($<12\%$) or heavier ($>12\%$) of game bat weight may actually decrease a baseball player's swing velocity (Szymanski, 2009). The commercial donut ring that is often used in on-deck circles has been shown to slow down bat swing velocity and should be avoided (DeRenne, 1992; Southard, 2003).

Dabbs (2010) examined neuromuscular activation by using a vibration plate and its effect on bat speed for women softball players. They concluded that whole body vibration can be used in place of dry swings to achieve similar bat speeds.

Our study approaches swinging a bat similar to neuromuscular activation, although the main difference is the exercise treatment with the grips (e3 Swing Grips, BioGrip, Sacramento, CA) was designed, "to put the hands in an anatomically neutral position." Once the body has "a more favorable structural position," this may lead to better recruitment patterns of muscles and impact swing speed. Research has shown that a concept called concurrent activation potentiation (CAP) has been used to enhance prime mover performance via the simultaneous contractions of muscles remote from the prime mover such as jaw clenching (Hiroshi, 2003; Ebben, 2006). Jaw clenching, gripping, and other remote voluntary contractions (RVC's) have been theorized to be ergogenic for a prime mover.

In our study, the prime mover was the core musculature. The grip treatment being investigated does not use CAP or RVC's while swinging a bat, but instead uses the concept that gripping in a way that puts the hands in an "anatomically neutral position" will improve simultaneous contractions of prime movers, i.e. the core muscles, while doing the grip exercise treatment. Szymanski et. al (2009) has noted that swinging a baseball or softball bat is a sequential, rotational kinetic link movement that uses the entire body from the legs to the arms. The core is the link between the lower- and upper- body. The grip treatment is an intense isometric contraction of the core muscles with the intent of improving intramuscular coordination.

The purpose of this study was to evaluate the impact of an exercise treatment with grips designed to put the human skeleton in a "more advantageous position" (e3 Swing Grips, BioGrip, Sacramento, CA) on bat speed.

METHODS

Experimental Approach to the Problem

A single-blind, placebo-controlled, repeated-measures, counter-balanced study was designed to measure bat swing speed. After warming up, each participant performed three swings, and bat speed of each swing was recorded. Then, each participant was randomly assigned to: no exercise treatment (control), a triceps pushdown with a rope grip (placebo treatment), or grip exercise (experimental treatment), followed by seven swings with the bat (i.e. one-third of the participants received no exercise treatment first, one-third received triceps pushdowns first, one-third received the grip exercise treatment first). Bat speed of each swing was recorded. Following their swings, each participant rested for five minutes and repeated the seven swings.

During the second testing session, participants who performed no exercise treatment performed the grip exercise, participants that performed the grip exercise did the triceps pushdown, and participants that had triceps pushdown performed no exercise treatment, etc. During the third testing session, each participant received the treatment they had not yet received. Table 2-1 shows the design of the testing sessions.

To perform the grip movement pattern, each participant started with their toes pointed in slightly and their feet approximately hip width apart. Each participant held on to the grips which were suspended on the batting cage at approximately eye level height. After holding on to the grips, each participant placed their knuckles together and brought their elbows to the mid-line of their body (Picture 2-1). They performed six repetitions where they pressed down slightly on the grips while exhaling completely. Each repetition lasted for approximately 2-3 seconds.

To perform the placebo exercise, each participant did a triceps pushdown with a rope grip. They performed six repetitions and each repetition lasted for approximately 2-3 seconds.

Participants

The participants were volunteers from the University NCAA Division I softball and baseball teams. The participants were competitive baseball and softball players who were well trained in swinging a bat. Sixteen male baseball players (age 20.1 ± 0.9 years, weight 84.9 ± 8.7 kg, height 182.1 ± 6.3 cm) and 12 female softball players (age 20.1 ± 1.0 years, weight 72.2 ± 14.5 kg, height 169.1 ± 8.6 cm) took part in this study. All testing occurred in April and May of 2011 during softball and baseball season.

Exclusion criteria for the current study included, but were not limited to: age < 19 or >40 years and any injury that inhibited swinging a bat. This study was approved by the local

Institutional Review Board for the Protection of Human Subjects, and written consent was obtained from all participants prior to the collection of any data.

Experimental Procedures

Testing was completed at the University softball and baseball indoor batting cages. Bat speed was measured with a Doppler radar velocity sensor (Swing Speed Radar, Sports Sensors, Inc, Cincinnati, OH). The radar was set at a height corresponding to the plane of the bat swing, and bat speed was measured from in front of the batter's body. The distance to the radar was 1.5 meters.

On testing days, each participant was given 5 min to perform a consistent warm-up. Each participant was encouraged to warm-up like she/he would before batting practice or a game. After warm-up, the speeds of three swings were recorded with the radar (Swing Speed Radar, Sports Sensors, Inc, Cincinnati, OH) to give a point of reference on bat speed. Then, each participant performed the treatment for that day. Bat speed of each swing was recorded and the slowest and fastest swings for each participant were discarded and the other five swings for each condition were averaged to determine individual means for that treatment. Following the swings, each participant rested for five minutes and repeated their seven swings. Each participant rested approximately five seconds between each swing of their seven swings.

All testing sessions were counterbalanced with participants randomly assigned to treatment order. After completing the first round of trials, all participants had one day off between subsequent testing sessions.

Each participant chose their own bat for the testing protocol, but they were required to use the same bat for all testing sessions. The only stipulation was that all participants had to use

a metal bat because the radar that was used to measure bat swing speed was more accurate with metal bats compared to wooden bats.

Statistical Analyses

The statistical analyses were performed using SPSS 19 (SPSS, Inc., Chicago, Illinois). Mean bat speed data were analyzed using a one-way repeated-measures analysis of variance. Slowest and fastest swing velocities for each participant were discarded and the other five swings for each condition were used to determine means. An α level of 0.05 was used for all hypothesis tests. When significance was detected, a LSD post-hoc was used to detect the differences among treatments.

RESULTS

Treatment was given in three different sequences for the counter-balanced design, often referred to as a Latin-square design. The treatment order effect was non-significant for baseball ($F = .104, p = .90$) and for softball ($F = .314, p = .73$). Therefore the counter-balanced design was effective in controlling for any treatment order effect in the study.

The ANOVA indicated that there was significance difference ($F(2,44)=7.6, p<.001$) in bat speed for baseball players between the grip treatment when compared to the placebo and control. Table 2-2 presents means and SD of treatments on bat speed for baseball players.

The ANOVA for softball players indicated that there was no significance among treatments. Table 2-3 presents means and SD of treatments on bat speed for softball players.

Discussion

In this study we observed that the grip exercise treatment significantly increased mean bat speed immediately after performing the treatment 0.45 m/s (1 mph) and after five minutes of rest 0.9 m/s (2 mph) for collegiate baseball players when compared with a triceps pushdown treatment (placebo) and no treatment (control). There were no significant differences among treatments and bat speed for collegiate softball players.

Other studies observed the effect of training with overweighted and underweighted bats on bat swing velocity (DeRenne, C 1987; DeRenne, C 1982; DeRenne, C et al. 1995; DeRenne, C and Ohasaki, E 1983; Sergo, C and Boatwright, D 1993). They found that for advanced (collegiate and professional) baseball players, using specific resistance training with overweighted (+12%) and underweighted (-12%) bats over a 12 week period improved bat swing speed by 5-8 mph (DeRenne, 1995; DeRenne, 1983). It was advised that only well conditioned athletes with a good strength foundation utilize this form of specific bat swing velocity training (Szymanski, 2009). Baseball players with lower strength levels may improve their bat speed with almost any form of consistent bat speed training or simply by swinging a regulation baseball bat (Sergo, 1993).

Effect of resistance training on bat swing velocity has been examined (Schwendle, 1992; Szymanski, 2008; Szymanski, 2007; Szymanski, 2006; Hughes, 2004). They have found that for high school athletes, general periodized resistance training for three days a week for six weeks appears to be an effective means for increasing bat speed (Szymanski, 2006; Szymanski, 2009). Recent research has indicated that adding rotational medicine ball throws to a resistance training program has shown even greater improvements in bat velocity of high school baseball players compared to resistance training alone (Szymanski, 2007). Szymanski et al. (2009) has also noted

that training experience and age are important determinates when considering a safe and effective way to administer resistance training to athletes. It has been noted in other power development literature that an increase in strength alone may decrease vertical jump power if the skill to coordinate neuromuscular firing has also not been addressed (Bobbert, 1994). In other words, they concluded that resistance training exercises should be accompanied by exercises in which the athletes may practice with their altered muscle properties (Bobbert, 1994). Hence, it is important for any athlete undergoing resistance exercise to practice their skill, in this case, swinging a bat at game speed velocity.

This is the first study to report a significant difference in bat speed from an acute exercise treatment prior to swinging a bat for maximum swing speed velocity. Although this is the first study to show that a specific exercise treatment can increase bat speed in collegiate baseball players, the concept of isometric contractions used to enhance performance has been investigated by other researchers (French, 2003; Gullich, 1996). At any point in time, the performance of skeletal muscle is affected by its contractile history (Sale, 2002; French, 2003). An obvious effect of contractile history is fatigue, which impairs or impedes performance.

In contrast to fatigue, a phenomenon known as postactivation potentiation (PAP) has been shown to improve performance (Sale, 2002; Hamada, 2000a; Hamada, 2000b). The underlying premise of PAP is that prior heavy loading of skeletal muscle induces a high degree of neural stimulation that results in greater motor unit recruitment and higher rate of force development for several minutes afterward (up to 8-10 minutes), and, thus, improves speed and power performance (French, 2003; Sale, 2002; Hamada, 2000a; Hamada, 2000b). The neural stimulation achieved following heavy loading is greatest within fast, Type II muscle fibers, and thus PAP may hold the most benefit for athletes participating in events that require sudden, brief

efforts such as throwing, jumping, and hitting (French, 2003; Sale, 2002; Hamada, 2000a; Hamada, 2000b). There is also some research to show that PAP may improve synchronization of motor patterns (Shea, 1991).

This study employed the principle of PAP to the grip treatment (experimental treatment), which is an intense isometric contraction of the core musculature, as a means to increase bat speed. Since the grip treatment was an intense isometric contraction lasting for approximately 2-3 seconds with 6 repetitions (12-18 seconds total), it is possible that the minimal increase in bat speed .45 m/s (approximately 1 mph) following the treatment may be due to fatigue from the grip treatment. Five minutes of rest allowed for faster bat speeds .9 m/s (approximately 2 mph), which is in agreement with research that has shown performance may be improved when fatigue has dissipated faster than the rate PAP has decayed (Gilbert, 2001; Gullich, 1995; Young, 1998). In other words, bat speed may have increased to a larger degree if there were no fatigue. French (2003) found that 3 repetitions of 3 sec of maximal voluntary isometric contractions produced significantly higher jump height, maximal force, and acceleration impulse compared to 3 repetitions of 5 sec. French and colleagues (2003) stated that using repeated isometric contractions in which total volume of approximately 10 sec may be more beneficial than larger volumes (e.g., 15 sec) because they may induce less fatigue. This should be noted for further research.

It is interesting that although this study employed the principle of PAP to the grip treatment (experimental treatment) and to the triceps pushdown treatment (placebo treatment), only the grip treatment showed a significant change in bat speed. This may result from the targeted muscle for the placebo treatment being the triceps whereas the experimental treatment is the core musculature. Another possibility may be that the triceps pushdown treatment (placebo

treatment) may alter motor unit recruitment of the core musculature, the link between the upper body and lower body in the kinetic chain.

Although it is not possible to make definitive judgments using present data, it is interesting that the collegiate softball players did not make the significant increase in bat speed that was seen with the baseball players. Research has shown that maximal voluntary isometric contraction force is greater for men than for women (Kent-Braun, 1999; Hunter, 2001; Miller, 1993). This is a possible explanation of the differences we observed between collegiate softball players and baseball players. Although these are not primary concerns of this study, these findings should be noted for future research.

PRACTICAL APPLICATIONS

In this study we observed that the grip exercise treatment significantly increased mean bat speed immediately after performing the treatment 0.45 m/s (1 mph) and after five minutes of rest 0.9 m/s (2 mph) for collegiate baseball players, but not for softball players. This may lead to collegiate baseball players having more time to make decisions on a thrown pitch, make contact with a pitch, and increase batted-ball velocity. The ease and use of the grip treatment may be a practical way to incorporate intense isometric muscle contractions of the core musculature into practice or game conditions that enhance bat speed velocity.

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TABLES AND FIGURES

Table 1. Design of Testing Sessions

<u>1st Testing Session</u>	<u>2nd Testing Session</u>	<u>3rd Testing Session</u>
A – no exercise treatment	C – grip treatment	B – triceps pushdown
B – triceps pushdown	A – no exercise treatment	C – grip treatment
C – grip treatment	B – triceps pushdown	A – no exercise treatment
<ul style="list-style-type: none"> • After warming up, each participant had 3 dry swings that were recorded • Each participant was randomly assigned a treatment, followed by 7 dry swings that were recorded • Following a five minute rest, each participant had 7 more dry swings that were recorded 		

Table 2-2. Comparison of Means & SD of Treatments on Bat Speed for Baseball Players.

	Warm-up	Post Treatment	Post 5 min Rest
No Grip (m/s) (control)	33.3 ± 3.1	32.5 ± 3.1	33.3 ± 2.7
Triceps (m/s) Pushdown (placebo)	32.8 ± 2.6	32.3 ± 2.3	33.2 ± 2.7
Grip (m/s)	33.0 ± 2.5	33.4 ± 2.5*	34.0 ± 2.8*

*Significant difference (F(2,44)=7.6, p<.001) compared to placebo and control

Table 2-3. Comparison of Means & SD of Treatments on Bat Speed for Softball Players

	Warm-up	Post Treatment	Post 5 min Rest
No Grip (m/s) (control)	28.5 ± 2.1	28.5 ± 2.3	28.8 ± 2.2
Triceps (m/s) Pushdown (placebo)	28.5 ± 1.9	28.3 ± 1.8	28.3 ± 2.4
Grip (m/s)	28.5 ± 1.9	28.7 ± 1.5	28.9 ± 2.1



Figure 1

FIGURE CAPTIONS

Figure 1. Example of starting position for grip treatment.

CHAPTER 4

SPORTS PERFORMANCE AND POSTURE: REVIEW OF LITERATURE

ABSTRACT

BACKGROUND. Posture has the ability to influence many aspects of sports performance.

Postural control may be defined as being able to position the body in a manner in which mechanical efficacy is optimized and stress on body structures is minimized during static or dynamic movement.

LITERATURE. This review included 60 articles that met the criteria of “sports performance” and “posture” with the emphasis on running and weight lifting. Articles were excluded if the postural research was based upon an unhealthy population or the elderly.

FINDINGS. Acceleration for sprinting requires a forward lean of the body that requires optimal, not maximal, force application. This highlights the importance of postural control in sprinting.

Elite distance runners appear more symmetric than good distance runners, even though the body structure and movement of elite runners is not quite symmetrical. Positioning and postural control determine power output during lifting and are specific to the task. There are postural deviations that are often indicative of high-level athletes based on an athlete’s specific sport. It is questionable to promote resistance exercises alone to correct postural deviations, such as scoliosis, kyphosis, excessive lumbar lordosis, or abducted scapulae. Any potential postural change from resistance exercises alone would probably be offset with daily living activities.

CONCLUSIONS. The literature is clear that there are sport-specific postural deviations. It is unclear if these postural deviations lead to better performance or if a specific training plan should be developed to help build and maintain a more balanced body posture. **FURTHER**

RESEARCH. Posture is a multi-factorial topic that is still not yet fully understood. It may be advisable for future research to look into the role of the nervous system and its connection to movement patterns along with its effect on posture control of static and dynamic movement.

Key Words: balance, exercise technique, running, biomechanics, kinematics, power

BACKGROUND

One of the most important, yet most neglected, variables in athletic performance is posture and proper positioning of the body (Schexnayder, 2000). In most athletic events, the application of force is of critical importance and proper posture is a prerequisite to maximal force production (Schexnayder, 2000). Not only is posture important for performance, but athletic trainers and physical therapists have stressed the importance of posture and have often linked injuries to poor posture (Hennessy, 1993; Sahrman, 2002).

Correct posture has been defined as a situation in which the center of gravity of each body segment is placed vertically above the segment below and creates a state in which muscular symmetry provides stability and guards the body against injury (Bloomfield, 1998; Watson, 2000; Britnell, 2005). Good posture helps optimize musculoskeletal health and performance (Bloomfield, 1998; Britnell, 2005; Hrysomallis, 2001; Sahrman, 2002; Watson, 2000). A body that has correct posture will be in a state of equilibrium. Equilibrium is a state characterized by balanced forces and torques in which there is no wasted energy or unnecessary force production to accommodate body segments that are out of proper alignment (Bloomfield, 1998; Britnell, 2005; Hall, 2007). Correct posture allows for proper or optimal energy expenditure during static and dynamic activities (Kritz, 2008).

The focus of most posture research is related to health and productivity. Within sports, the biomechanical rationale for achieving and maintaining optimal posture is to move effectively, free of impairment and dysfunction (Kritz, 2008). This will allow an athlete not to waste energy and allow for maximal force production (Schexnayder, 2000).

Within the context of this review, postural control will be the focus. Postural control is a primary component of successfully completing both activities of daily living and participating in sports (Murphy, 2003). Postural control may be defined as being able to position one's body in a manner in which mechanical efficacy is optimized and stress on the body's structures are minimized. The goal of posture in sports performance is to maximize force production and minimize the possibility for injury.

LITERATURE

This review included articles that met the criteria of "sports performance" and "posture" with the emphasis on running and lifting. Articles were excluded if the postural research was based upon an unhealthy population or the elderly.

A search for "sports performance" and "posture" in PubMed (Medline) produced 473 references. When limited to "running" it was reduced to 38. When limited to "lifting" it was reduced to 19.

A search for "sports performance" and "posture" in ScienceDirect produced 8,065 references. When limited to "skeletal alignment" it was reduced to 533. When limited to "running, lifting, and jumping" it was reduced to 55. When further restricted to "sport med, athlete, gait posture, motion analysis, posture, sixteenth annual" it was reduced to 12.

A search for "sports performance" and "posture" in Scirus produced 49,542 references. When limited to "skeletal alignment" it was reduced to 3,995. When limited to "running, lifting, and jumping" it was reduced to 372. When further restricted to "biomechanics, ground reaction force, muscle strength, kinematics, elite athletes" it was reduced to 11.

These references were screened and those papers concerning posture and sports performance were selected for further study. The literature retrieved in this way was supplemented with references from reviews with a broader scope and studies cited in the previously retrieved papers. In all, 60 papers were selected for review.

FINDINGS

In this review, we will cover the topics of sports performance concerning:

- Posture and running performance
- Posture and resistance exercises
- Factors affecting postural control or stability
- Posture and sport specific adaptations
- Possibility of postural realignment with resistance exercise.

Posture and Running

There is very little research into posture and its effects on running performance. Many of the biomechanical studies of running focused on describing and understanding how an elite runner moves, not necessarily on the posture of the runner. This could be due to the fact that posture is often subjectively measured and as Kritz et al. (2008) has stated, the relationship between static posture and dynamic movement is unclear.

Sprinting is associated with short distance and faster speeds. Most of posture research into sprinting has focused on sprint stance and postural control during the start (Johnson, 2010; Kugler, 2010). The goal of any sprint is to optimize force production into the ground to maximize speed (Schexnayder, 2000). Research on sprint start has found that a staggered stance

(regardless of stepping back) produced the greatest sprinting velocity over 4.6 meters (15 ft) (Johnson, 2010). Although taking a false step or a step backwards sounds counterproductive, it results in a more forward position of the body's center of mass, more horizontal power production, and better use of the stretch-shortening cycle (Johnson, 2010; Brown, 2004; Chu, 1993; Cronin, 2007; Frost, 2008; Salo, 2004). Kugler et al. (2010) also examined how body position affected speed in acceleration. They found that faster participants utilized a more posterior foot plant or a longer ground contact time. Both strategies created a greater forward lean of the body which resulted in greater horizontal propulsive force vectors forward (Kugler, 2010). Quicker accelerations were generated by lower ground reaction forces, but more forward-oriented forces (Kugler, 2010). In other words, acceleration requires a forward lean of the body that requires optimal, not maximal force application (Kugler, 2010).

In terms of distance running, Cavanagh et al. (1977) found that elite athletes appeared more symmetric than good runners, even though the body structure and movement of elite distance runners was not quite symmetrical. This leads us to assume that an elite distance runner has better postural control, hence they do not have to constantly fight gravity to re-adjust their body segments, but instead can create propulsive forces that help move them forward with the least amount of energy wasted.

Carpes et al. (2010) examined the literature concerning leg preference and bilateral asymmetry during running and cycling. They found that regardless of posture or structure, asymmetries often occur at self-selected movement frequencies. Most of these asymmetries often disappear when athletes are forced to perform at higher frequencies, intensities, or with greater power outputs (Carpes, 2010). This is an interesting observation because most elite athletes spend more time running at higher intensities than good runners do.

Recently a study was conducted which investigated the impact of a hand-grip device designed to put the human skeleton in a “more favorable anatomical position,” on 3.2-kilometer (2-mile) running performance by measuring time and counting steps (Illian, 2011b). In this study no change in running time performance was observed with the hand-grip device and only a significant change in step count for participants who could run 3.2 kilometers (2 miles) under 14 minutes. The researchers concluded that if a participant is able to run 3.2 kilometers under 14 minutes, then using the postural fitness grips may decrease the number of steps required to run a given distance, but may not improve time (Illian, 2011b).

Posture and Lifting

The purpose of resistance exercise for athletes is to increase the functional capabilities of an individual that allows her/him to overcome the stresses that are placed on them during their respective sport. Resistance exercise is a tool to enhance performance. Much of the research concerning posture and resistance exercise is an attempt to better understand how the body parts synergistically work and how posture contributes to maximizing force production as well as to minimize injuries.

Some researchers have focused their attention on studying powerlifters and Olympic weight lifters in order to determine the influence of posture on performance. Hales et al. (2009) compared the back squat and deadlift under maximal loads to assess kinematical differences and to determine if there was a cross-over effect between lifts. There were some large postural differences between the squat and deadlift under maximal conditions. Relative trunk angles were 40.58 ± 6.29 degrees for the back squat and 58.30 ± 7.15 degrees for the deadlift. Relative joint angles in degrees were reported at the sticking point of each lift for the hip, knee, and ankle.

Their results indicated that the back squat represented a synergistic or simultaneous movement, whereas the deadlift demonstrated a sequential or segmented movement. During the back squat, lifters were able to maintain lumbar lordosis with a slightly arched but rigid spinal column. During the deadlift, the trunk was unable to maintain lumbar lordosis, and a prominent kyphotic condition was evident at the thoracic region of the spinal column, which produced a rounded back posture (Hales, 2009). The kinematic analysis of the squat and the conventional deadlift indicated the two lifts were clearly different from each other.

Hales et al. (2009) also noted that there were two methods of deadlifting: a leg-lift and a back-lift. The leg-lift method demonstrates a reduced load on the lumbar spine, which is considered safer, but the knees are heavily loaded, whereas the back-lift style subjects the lumbar region to extremely high forces and moments (Hales, 2009). Benjjani et al. (1984) noted that the leg-lift method of the deadlift approaches the back-lift technique when lifting near maximal loads, caused in part, by biomechanical constraints and the inability to maintain posture, or lumbar lordosis. Other researchers noted the same thing (Schipplein, 1990; Schultz, 1981). During heavy deadlifting, the leg-lift method does not appear to be the preferred strategy and may not even be possible (Schipplein, 1990; Schultz, 1981).

Researchers have investigated the effects of weightlifting shoes compared to running shoes during a squat. While a number of kinematic parameters were similar between wearing weightlifting shoes or running shoes, when wearing the weightlifting shoes the participants maintained a more vertical body position and the bar and hip were displaced less, suggesting a more erect trunk posture (Fortenbaugh, 2010). The largest practical difference was in the horizontal trunk movement. The optimal bar path for the squat is a strictly vertical line. In reality, there will always be some anterior bar displacement accompanied by some posterior hip

displacement, creating a forward trunk lean. The goal is to minimize these movements to reduce the amount of trunk lean (Fortenbaugh, 2010). During testing, nearly all participants mentioned to the research staff that they felt the squats were much easier to perform when wearing weightlifting shoes (Fortenbaugh, 2010). This is important to note because research has shown that higher-skilled lifters have less trunk lean than their lower-skilled counterparts (McLaughlin, 1977). The National Strength and Conditioning Association's (NSCA) position paper also recommends minimal trunk lean to improve performance and reduce the risk of injury (Chandler, 1991).

One of the goals of resistance training is to maximize power production. Many methods have been employed to try to accomplish this goal. In a recent study, researchers were investigating the effect of the positioning of external resistance and its effect on the kinematics and kinetics of weighted jumps (Swinton, 2010). Customarily, when athletes perform weighted jumps with substantial resistance, the external load is positioned on the posterior aspect of the shoulder using a straight barbell. This study showed that changing the position of the load from the shoulders to arms' length held at the side of the body using a hexagonal barbell, resulted in significant increases in peak force, peak power, and peak rate of force development, with a trend towards higher velocity, average force and average power values. The results also demonstrated that the hexagonal barbell could be used to apply resistances equal to, or greater than, that obtainable with a straight barbell (Swinton, 2010). When comparing unloaded and weighted jumps (performed with a straight barbell in this study) the results supported previous research (Cormie, 2007; Bevan, 2010) showing that maximum power is produced during unloaded jumps. In contrast, when comparing unloaded and weighted jumps performed with the hexagonal barbell, the results showed that maximum power was produced with a load of 20% 1RM

(Repetition Maximum) (Swinton, 2010). Results demonstrated that the positioning of the external resistance had a significant effect on the kinematic, kinetics, and power production of weighted jumps (Swinton, 2010).

In a recent study, researchers investigated the impact of an isometric postural exercise on bat speed (Illian, 2011a). They observed that the grip exercise treatment that utilized a postural isometric exercise significantly increased mean bat speed immediately after doing the treatment 0.45 m/s (1 mph) and after five minutes of rest 0.9 m/s (2 mph) for collegiate baseball players when compared with a triceps pushdown treatment (placebo) and no treatment (control), but not for softball players. It was concluded that the ease in use of the postural grip treatment may be a practical way to incorporate intense isometric muscle contractions of the core musculature into practice or game conditions as a means of enhancing bat speed velocity (Illian, 2011a).

Factors affecting Postural Control or Stability

Research has looked at factors that affect postural control or stability. Balance and posture often go hand-in-hand. Balance is actively controlled by the central nervous system, which is able to call into action relevant postural muscles when needed (Nardone, 1990).

Some investigators have examined how the body fatigues and still maintains postural control. When a muscle activates in advance of a bodily movement to control stability, it is referred to as anticipatory postural adjustments (Strang, 2008). Anticipatory postural adjustments have been demonstrated in situations where fatigue is caused by isometric contractions (Allison, 2002; Vuillerme, 2002) and by exhausting aerobic exercise (Strang, 2008). Research has shown that the muscles of the trunk and lower-body act together to maintain postural stability (Allison, 2002; Vuillerme, 2002). These findings provide tentative support for

the notion that earlier anticipatory postural adjustments constitute a functional adaptation by the central nervous system to maintain postural stability in the presence of fatigue (Strang, 2008).

The reason anticipatory postural adjustment onset can be earlier in the presence of fatigue is not known, but it is speculated that the onset may constitute a functional and safety adaptation by the motor system to maximize stability (Allison, 2002; Strang, 2008; Vuillerme, 2002).

The reason postural stability is so important is that it may decrease the risk of injury. Within sports, the goal is to know how postural stability plays a role in injury prevention or when increased risks for injuries may occur. A study by Reimer et al. (2010) discovered that functional muscular fatigue in the lower-limb impairs postural control during single-leg stance on an unstable platform in young, active adults. Although established literature had demonstrated that the hip musculature is more important to the maintenance of balance (Gribble, 2004a; Gribble, 2004b; Salvati, 2007), the Reimer et al. (2010) results indicated that fatigue of the ankle and hip created similar impairments in single-leg stance postural control. The established literature had used isokinetic protocols whereas Reimer et al. (2010) used a functional fatigue protocol (closed kinetic chain). Rehabilitative and strength training programs should focus on the entire lower extremity because deficits in any muscle group may lead to an increased risk of injury (Reimer, 2010). These results suggest that when muscular fatigue is present, postural control is decreased, hence the risk for injury increases.

Apart from fatigue, additional factors may also contribute to reduced postural stability following exercise. It may be important for coaches, trainers, and athletes to know some possible causes of reduced postural stability as a way of minimizing the chance for injury. Research has shown that treadmill running tends to disturb postural stability, possibly because of the more excessive head movement and disturbance of the vestibular, somatosensory and visual

information centers (Derave, 2002; Lepers, 1997; Hashiba, 1998). For coaches or athletes who often use treadmills, it may be prudent not to challenge postural stability following treadmill use. Dehydration has also been shown to impair postural control (Guachard, 2002; Holtzhasen, 1995).

Only a few studies have examined athletes' postural control and most of the athletes studied needed special skills in balance control (Golomer, 1999; Vuillerme, 2001). In these studies, it has been observed that professional dancers and gymnasts are significantly more stable and less dependent on vision for postural control than untrained subjects (Golomer, 1999; Vuillerme, 2001). In a recent study of triathletes competing in an ironman race, Nagy et al. (2004) found that triathletes were significantly more stable and less dependent on vision for postural control than subjects who engaged in regular physical activity.

Posture and Sport Specific Adaptations

Bloomfield and Watson have devoted a substantial amount of time to investigating sport-specific postures. They have identified postural deviations that are often indicative of high-level athletes based on an athletes' specific sport (Bloomfield, 1998; Watson, 1983). These postures are often valued by coaches who believe that certain abnormal postural deviations may increase mechanical advantage and improve performance (Kritz, 2008).

The most common postural deviation for the shoulder is abducted scapulae and rounded shoulder posture (Bloomfield, 1998). This posture can be found mainly in overhead throwing athletes and athletes involved in contact sports (Kritz, 2008). It is alleged that this posture is partly attributed to an increased length of the serratus anterior muscle, which from a practical and biomechanical perspective may allow throwing athletes to increase the time and distance that force can be applied resulting in a harder or longer throw (Sahrmann, 2002). On the other hand,

Kebaetse et al (1999) found that individuals who had a rounded shoulder posture with altered thoracic symmetry could not achieve full active range of motion in shoulder elevation and were more prone to injury.

The most commonly reported sport-specific postural adaptations of the trunk and hip region are lumbar lordosis and anterior pelvic tilt (Bloomfield, 1998; Watson, 1983). The proposed advantage of having anterior pelvic tilt and resulting lordotic posture are speculated to increase hip extension, which allows the athlete who needs to run and jump to apply force over a longer time resulting in a greater impulse force (Kritz, 2008). Lumbar lordosis is also significantly greater in athletes who participate in football and soccer in comparison with other sports (Watson, 1983). However, athletes with severe anterior pelvic tilt have reported increased incidence of low back pain (Nadler, 1988; Sahrman, 2002).

The most common lower-leg postural observations are that athletes involved in sports requiring quick steps within a short distance are likely to possess a pigeon toe posture of the feet (Sahrman, 2002). It is speculated that this adaptation occurs due to tibial torsion shortening the hamstring muscle group, preventing the individual from taking long steps (Sahrman, 2002). It has also been observed that swimmers often display pigeon toe and knee hyperextension (Sahrman, 2002). There is no evidence to support any benefits of lower-limb postural abnormalities in swimmers, but it is speculated that the pigeon toe posture and knee hyperextension may allow for greater propulsive forces from the feet and a greater kicking range of motion, hence more work performed during each kick (Kritz, 2008).

It appears that some postures thought to be “faulty” may offer athletes a sport specific advantage (e.g., anterior pelvic tilt for sprinters and jumpers, hyperextension of the knees for swimmers). Kritz et al. (2008) stated that it is not clear whether sport-specific postural

deviations are truly beneficial to sport performance or simply an adaptation of committed sport participation void of specific training interventions designed to build a balanced body with better posture.

Possibility of Postural Realignment with Resistance Exercise

It has been stated that if body segments are held out of alignment for extended periods of time, the muscles will rest in a shortened or lengthened position (Bloomfield, 1994) and with considerable time, adaptive shortening or lengthening may result (Novak, 1997). Muscles that become shortened are often short and strong, whereas the opposing muscles are pulled into a lengthened and weakened position (Kendall, 1993). The change in muscle length and tension may influence posture alignment (Hrysomallis, 2001).

It has been speculated that excessively working one muscle group without working the opposing muscles may lead to muscle imbalances that may lead to postural deterioration (Cibrario, 1997). An example of this is excessive bench pressing that works the chest musculature without working the back muscles, allegedly leading to poor, rounded shoulder posture. It has also been suggested that adaptive muscle shortening may result from overuse of a muscle, especially in a shortened state (Herbert, 1993; Janda, 1993).

We have already noted that there are specific postural deviations for specific sports (Bloomfield, 1998; Watson, 1983). It has been suggested that using resistance exercises to counteract the postural deviations by strengthening the weak, lengthened muscle group may result in corrective shortening, along with stretching the short opposing muscle to help repositioning of skeletal alignment (Kendall, 1993).

Many resistance exercises have been prescribed in an attempt to correct a number of postural deviations including: scoliosis, kyphosis, excessive lumbar lordosis, and abducted

scapulae (Bloomfield, 1994; Holloway, 1994; Kendall, 1993; Zatsiorsky, 1995). Based on a review of resistance exercise and posture realignment by Hrysomallis et al. (2001), it is questionable as to whether resistance training alone will produce an adaptive shortening of a muscle and hence elicit postural changes. Even if the tight agonist is lengthened by a stretching program, there is limited evidence to suggest that resistance training of the antagonist will lead to adaptive shortening and a change in static posture. It appears that the frequency and duration of exercise programs are inefficient to produce adaptive shortening of muscles. Even if individuals could exercise long enough in restricted range-of-motion, any potential length adaptations would probably be offset by daily living activities which often require full range-of-motion (Hrysomallis, 2001). Based on the literature review by Hrysomallis et al. (2001), it is not recommended to try to promote strengthening exercises to correct postural deviations, such as scoliosis, kyphosis, excessive lumbar lordosis, and abducted scapulae.

Since posture is maintained by constant low-level neural input of the postural muscles it has been speculated that muscular endurance is more important than muscular strength (Foss, 1998; McConnell, 1993). One research study subjectively investigated the effects of lumbar posture on twenty-three elite gymnasts and twenty-eight controls. In this study, isometric abdominal endurance was measured and the researchers concluded that there was no significant relationship between muscle endurance and lumbar posture. Although, the researchers noted that postural screening and postural muscle retraining in gymnasts with poor posture and low back pain may be relevant (Mulhearn, 1999).

It is interesting to note that in the conclusion of the ability of resistance exercise for posture realignment Hrysomallis et al. (2001) noted that “daily living activities” may offset any potential changes. In the conclusion of Mulhearn et al. (1999), it is noted that “postural muscle

retraining” may be relevant. It seems apparent in both of their conclusions that for any corrective program to be truly beneficial at correcting postural deviations, then retraining a person to move differently than she/he has for many years may be a necessity in seeing any real postural changes. It lends itself to the idea that the nervous system has been programmed to move a certain way for many years and only by retraining the nervous system via daily movement patterns can a person correct postural deviations. It is also conceivable that changing a long-held posture might hurt sports performance.

CONCLUSIONS

- Acceleration for sprinting requires a forward lean of the body which requires optimal, not maximal force application (Kugler, 2010). Research on sprint starts has found that a staggered stance (regardless of stepping back) produced the greatest sprinting velocity over 15 feet (Johnson, 2010).
- Elite distance runners appeared more “symmetric” than good runners, even though the body structure and movement of elite runners are not quite symmetrical (Cavanagh, 1977). Asymmetries often disappear when athletes were forced to perform at higher frequencies, intensities, or with greater power outputs (Carpes, 2010).
- Positioning and postural control of the body determine power output during resistance exercises (i.e. squat, deadlift, etc). Results demonstrated that positioning of the external resistance or loading had a significant effect on the kinematic, kinetics, and power production of weighted jumps (Swinton, 2010).
- There are postural deviations that are often indicative of high-level athletes based on an athletes’ specific sport (Bloomfield, 1998; Watson, 1983). Kritz et al. (2008) stated that it

is not clear whether sport-specific postural deviations are truly beneficial to sport performance or simply an adaptation of committed sport participation void of specific training interventions designed to build a balanced body with better posture.

- It is questionable to promote resistance exercises alone to correct postural deviations, such as scoliosis, kyphosis, excessive lumbar lordosis, and abducted scapulae (Hrysomallis, 2001).

FURTHER RESEARCH

The idea that muscular strength or endurance can be tested for and a relationship can be established with low back pain or any other postural deviation may be misleading. Postural deviations which have often been researched are deviations that have been developed over years, especially the postural deviations seen in sports. These athletes may have developed them through countless years of repetitive motions not counteracted by opposing motions, or incorrect movement patterns that have ingrained in the athletes improper neurological proprioceptive awareness that cannot be changed by strengthening or lengthening a muscle alone, but must be addressed in every movement pattern that she/he makes throughout a day. Posture is a multi-factorial topic that is still not yet fully understood. It may be advisable for future research to investigate the role of the nervous system and the connection to movement patterns along with their subsequent effect on posture control of static and dynamic movement.

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CHAPTER 5

DISCUSSION OF POSTURE AND SPORTS PERFORMANCE

The purpose of the investigations, presented in chapters 2 and 3, was to examine the influence of a hand-grip device (e3 Fitness Grips, BioGrip, Sacramento, CA) on force production. In chapter 2, this study investigated the impact of a hand-grip device (e3 Fitness Grips, BioGrip, Sacramento, CA) designed to put the human skeleton in a “more favorable anatomical position,” on 3.2-kilometer (2-mile) running performance by measuring time and counting steps. In chapter 3, this study evaluated the impact of an isometric exercise treatment with grips designed to put the human skeleton in a “more advantageous position” (e3 Swing Grips, BioGrip, Sacramento, CA) on bat speed. In chapter 4, a review of literature was conducted examining posture and sports performance.

Overall Discussion

The results of these studies indicate that posture and sports performance is a complex multi-factorial topic that is still not fully understood. The difficulty with assessing posture and sports performance is that a person’s daily postural habits affect their posture and their posture influences the way they move (Cook, 2003). Posture and daily movement patterns go hand-in-hand and sports participation is often a large part of daily movement patterns for high-level athletes. Literature has identified postural deviations that are often indicative of high-level athletes based on an athletes’ specific sport (Bloomfield, 1998; Watson, 1983). One of the paradoxes of sports performance that may cause a hindrance to improving posture for athletes is the principle of efficacy. To be a high-level athlete, efficacy is usually a prerequisite. Most motions that an athlete becomes efficacious at are extremely repetitive (i.e. running forward,

throwing with their dominant arm, etc.). Unfortunately, without intervention, opposing muscle groups can inhibit the other in an attempt to make a movement pattern more efficient (Cook, 2003). If one movement pattern becomes extremely efficient, there is an increased chance of the muscles that recruit the opposing movement pattern to become weak or inhibited. If this occurs, abnormal postural may develop which may eventually lead to injuries or pain.

Coaches, strength coaches, and athletic trainers are often fearful to make any recommendations to change any sport-specific postural deviation because there is a long held belief that abnormal postural deviations may increase mechanical advantage and improve performance (Kritz, 2008). Kritz et al. (2008) stated that it is not clear whether sport-specific postural deviations are truly beneficial to sport performance or simply an adaptation of committed sport participation void of specific training interventions designed to build a balanced body with better posture. The coaching theory that states, “If it is not broke, then don’t fix it” may make it extremely difficult to investigate postural interventions in high-level athletes. It is also conceivable that changing any long-held posture might hurt sports performance, at least for a certain amount of time. Most coaches and athletes are not willing to see any decrease in performance, even for a short period of time, unless they are completely sure it will lead to long term success.

In athletic training and sports performance, there has been a strong interest in prehabilitation, or the focus on minimizing the chance for injury before any injury occurs. This may be the fundamental mindset needed to help design and implement postural assessments and specific training programs designed to build a balanced body that utilizes proper posture for enhanced performance and minimizing injuries.

It seems that for any corrective program to be truly beneficial at correcting postural deviations, then retraining a person to move differently than she/he has for many years may be a necessity in seeing any real postural changes and reducing injuries. Posture and postural control lends itself to the idea that the nervous system has been programmed to move a certain way for many years and only by retraining the nervous system via daily movement patterns can a person correct postural deviations. One of the challenges of posture is to develop principles to guide correct posture while understanding the uniqueness of each individual and their needs in their specific sport.

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APPENDIX

April 1, 2011

Office for Research
Institutional Review Board for the
Protection of Human Subjects

Travis Illian
Department of Kinesiology
College of Education
The University of Alabama



Re: IRB # 11-OR-108-ME "Evaluation of Hand Position on Endurance Running Performance"

Dear Mr. Illian:

The University of Alabama Medical Institutional Review Board has granted approval for your proposed research

Your application has been given expedited approval according to 45 CFR part 46. Approval has been given under expedited review category 7 as outlined below:

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Your application will expire on March 31, 2012. If your research will continue beyond this date, complete the relevant portions of Continuing Review and Closure Form. If you wish to modify the application, complete the Modification of an Approved Protocol Form. When the study closes, complete the appropriate portions of FORM: Continuing Review and Closure.

Please use reproductions of the IRB approved informed consent form to obtain consent from your participants.

Should you need to submit any further correspondence regarding this proposal, please include the above application number.

Good luck with your research.

Sincerely,

Director & Research Compliance Officer
Office for Research Compliance
The University of Alabama



152 Rose Administration Building
Box 870117
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(205) 348-8461
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April 1, 2011

Office for Research
Institutional Review Board for the
Protection of Human Subjects

Travis Illian
Department of Kinesiology
College of Education
The University of Alabama

THE UNIVERSITY OF
ALABAMA
R E S E A R C H

Re: IRB # 11-OR-109-ME "Exercise Treatments for Increased Bat Swing Speed"

Dear Mr. Illian:

The University of Alabama Medical Institutional Review Board has granted approval for your proposed research

Your application has been given expedited approval according to 45 CFR part 46. Approval has been given under expedited review category 7 as outlined below:

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

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Good luck with your research.

Sincerely,



152 Rose Administration Building
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