THE ACUTE HORMONAL RESPONSE TO THE KETTLEBELL SWING EXERCISE

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The purpose of this investigation was to examine the acute hormonal response to a bout of kettlebell swing exercise. Ten healthy men (19-30 y, 23.6 ± 3.5 y, 174.6 ± 5.7 cm, 78.7 ± 9.9 kg) who were engaged in resistance training at least twice per week but were inexperienced with kettlebell swings participated in this study. Participants were familiarized with the kettlebell swing exercise during an initial visit. During the subsequent experimental protocol visit, participants performed 12 rounds of 30 seconds of 16-kg kettlebell swings alternated with 30 seconds of rest. Heart rate (HR) and rating of perceived exertion (RPE) were measured at the end of every round of swings. Fasted blood samples were collected pre-exercise (PRE), immediately post (IP), 15 minutes post (P15), and 30 minutes post exercise (P30) and analyzed for total testosterone (T), growth hormone (GH), cortisol, and lactate concentrations. Participants completed a total of 227 ± 23 swings (average swings per round: 19 ± 2). HR and RPE increased significantly ($P < 0.05$) throughout the exercise protocol. Lactate concentrations were significantly increased at all post exercise time points compared to PRE. T was significantly increased at IP compared to PRE. GH was significantly increased at IP, P15, and P30 compared to PRE. Cortisol was significantly increased at IP and P15 compared to PRE. 12 rounds of 30 seconds of kettlebell swing exercise induced an acute increase in T, GH, and cortisol concentrations in resistance trained men. Additionally, this exercise protocol induced a large increase in HR and lactate concentration. Thus, the kettlebell swing exercise might provide an effective method for simultaneous endurance and resistance training.

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TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	iii
INTRODUCTION	1
METHODS	4
RESULTS	8
DISCUSSION	12
PRACTICAL APPLICATIONS	16
APPENDIX A: IRB CONSENT FORM	18
APPENDIX B: VISIT 1 CHECKLIST	24
APPENDIX C: KETTLEBELL SWING DATA COLLECTION SHEET	26
APPENDIX D: BLOOD SAMPLE HB, LACTATE, AND HCT	29
APPENDIX E: HORMONE ANALYSIS SHEET	31
APPENDIX F: MEDICAL HISTORY QUESTIONNAIRE	33
REFERENCES	36

INTRODUCTION

Recent years have provided strength and conditioning professionals with a variety of athletic preparation tools and modalities. Among such tools is the kettlebell, an implement used in Russia for many years prior to its recent popularization in the United States. Currently the kettlebell is used in fitness programs such as Crossfit and Pavel Tsatsouline's Russian Kettlebell Challenge as well as in some strength and conditioning programs. The offset center of gravity and unique construction of the kettlebell provide the user a tool that is suitable for ballistic, full body exercise (Jay et al., 2011). Only a few studies have investigated the efficacy of kettlebell training. Based on these studies, it appears that kettlebell training can improve maximal and explosive strength (Lake & Lauder, 2012), performance in Olympic weightlifting and powerlifting (Manocchia, Spierer, Lufkin, Minichiello, & Castro, in press; Otto, Coburn, Brown, & Spiering, 2012), and aerobic capacity (Farrar, Mayhew, & Koch, 2010; Hulsey, Soto, Koch, & Mayhew, 2012); thus, kettlebell training may provide an efficient method for simultaneous endurance and resistance training.

The neuromuscular adaptations to resistance training are modulated by the endocrine milieu and acute hormonal response to each exercise bout (Hansen, Kvorning, Kjaer, & Sjogaard, 2001; Kvorning, Andersen, Brixen, & Madsen, 2006; Ronnestad, Nygaard, & Raastad, 2011). Concentrations of circulating testosterone, growth hormone, cortisol, and other hormones are increased in response to an acute bout of heavy resistance exercise (Kraemer, Noble, Clark, & Culver, 1987; Kraemer et al., 1998; Linnamo, Pakarinen, Komi, Kraemer, & Hakkinen, 2005; Smilios, Pilianidis, Karamouzis, & Tokmakidis, 2003). A greater hormonal response to resistance exercise sessions may lead to greater physiological adaptations, such as increases in strength (Hansen et al., 2001; Ronnestad et al., 2011). Acute administration of

testosterone increases protein synthesis in young, pre-pubertal boys (Mauras et al., 1994) and supraphysiologic doses of testosterone improve muscle size and strength in healthy men, especially when combined with strength training (Bhasin et al., 1996). Conversely, when endogenous testosterone production is suppressed, lean body mass and muscular strength improvements in response to resistance training are attenuated (Kvorning et al., 2006). Designing training protocols that maximize the acute hormonal response to exercise might be important to achieve optimal physiological training adaptations.

The magnitude of the hormonal response to resistance exercise depends in large part on the acute program variables, including intensity (Raastad, Bjoro, & Hallen, 2000; Schwab, Johnson, Housh, Kinder, & Weir, 1993), volume (Hakkinen & Pakarinen, 1993; Ratamess et al., 2005; Smilios et al., 2003), duration of rest period (Ahtiainen, Pakarinen, Alen, Kraemer, & Hakkinen, 2005; Kraemer et al., 1990), and exercise mode (Tremblay, Copeland, & Van Helder, 2004). Exercise mode describes specific characteristics of the exercise, including the equipment used, how the exercise is performed, and the specific movement selected. Of primary importance to the magnitude of the hormonal response are the total volume of work performed and the amount of muscle mass used during an exercise, the latter of which is predominantly determined by exercise selection. Specifically, resistance exercises using greater amounts of muscle mass and resulting in greater volume of work elicit a higher hormonal response than those using a smaller amount of muscle mass (Hansen et al., 2001; Migiano et al., 2010; Volek, Kraemer, Bush, Incledon, & Boetes, 1997). Resistance exercises utilizing small amounts of muscle mass exhibit little to no hormonal response (Migiano et al., 2010; Spiering et al., 2009; Wilkinson, Tarnopolsky, Grant, Correia, & Phillips, 2006). Appropriate exercise selection, particularly

inclusion of resistance exercises that involve a large muscle mass, is important to achieve the optimal acute hormonal response.

The kettlebell swing is an exercise in which the participant uses either one or two arms to swing a kettlebell from between the legs to approximately eye level (Tsatsouline, 2006). This exercise is performed with neutral spinal alignment and relies on the muscles of the posterior chain (i.e., gluteal, hamstring, and back extensor muscles) as the prime movers. Thus, the kettlebell swing involves a large muscle mass and results in substantial muscular activation in the posterior chain and abdominal muscles (McGill & Marshall, 2012). Because of this large muscle mass involvement, kettlebell swing exercise could induce an acute increase in hormones that are involved in modulating neuromuscular adaptations to training (e.g., improvements in performance). Despite the current widespread use of kettlebell training among strength and conditioning professionals, and the importance of the acute hormonal response to subsequent resistance exercise adaptations, the hormonal response to kettlebell exercise has not been examined. Therefore, the purpose of this study was to examine the acute hormonal response to kettlebell exercise.

METHODS

Experimental Approach to the problem

This investigation evaluated the acute hormonal response to a kettlebell swing protocol used in previous investigations of physiological responses and adaptations to kettlebell swing exercise (Jay et al., 2011; Lake & Lauder, 2012). Ten men performed 12 rounds of 30 seconds of kettlebell swings alternated with 30 seconds of rest. A 16 kg kettlebell (Perform Better, Cranston, RI) was used by all participants because it is the recommended starting weight for men (Tsatsouline, 2006) and has been used in other studies evaluating its effects on strength and aerobic response (Farrar et al., 2010; Lake & Lauder, 2012). Fasted blood samples were collected via intravenous catheter prior to the warm up, immediately post exercise, 15 minutes post exercise, and 30 minutes post exercise, and were analyzed for testosterone (T), growth hormone (GH), cortisol (C), myoglobin, and lactate concentrations. Additionally, blood samples at PRE were analyzed for creatine kinase concentrations to help determine the presence of recent muscle damage.

Participants

Ten healthy, recreationally-trained men (19-30 y, 23.6 ± 3.5 y, 174.6 ± 5.7 cm, 78.7 ± 9.9 kg) volunteered for this study. Participants attested that they had engaged in resistance exercise for at least the previous 3 months (≥ 2 times a week) and had no history of anabolic steroid use. Additionally, the participants had little to no previous experience with the kettlebell swing exercise. The participants completed a medical history questionnaire to help determine their eligibility for the study. Exclusion criteria included any injuries or limitations that would prevent exercise involvement as well as the inability to safely complete the exercise protocol (e.g., unable to demonstrate proper exercise technique). All participants were informed of the risks and

benefits of participation in the study and subsequently provided written informed consent. The study was approved by University of North Texas Institutional Review Board.

Procedures

Session 1: Anthropometric measurements and familiarization. During Session 1, height, body mass, and body composition was measured. Body composition was determined using dual-energy X-ray absorptiometry (Lunar Prodigy General Electric Company, Madison, WI). Participants performed a standardized dynamic warm-up that consisted of lying knee to chest pulls, lying straight leg raises, quadruped scapulae retraction/protraction, quadruped thoracic rotations, quadruped hip circles, walking lunges with hip flexor stretch, lying hip abduction/external rotations, and glute bridges. After the warm-up, participants were familiarized with proper kettlebell swing exercise technique and safety procedures. All swings were performed on a non-slip, rubberized surface. Closed-toed shoes and athletic clothing were worn during all sessions.

Session 2: Kettlebell swing task (KST). One week following Session 1, participants arrived at the laboratory in a fasted condition in the early morning (0600-0700) and provided a urine sample for determination of hydration status using refractometry (Reichert, Depew, NY). Participants who were dehydrated (urine specific gravity $<1.020 \text{ g}\cdot\text{ml}^{-1}$) were provided cold water to drink. Following determination of hydration status, participants were provided a standard heart rate monitor chest strap to wear. A teflon catheter was subsequently inserted into an antecubital vein for the collection of approximately 20-ml blood samples at the following time points: pre-exercise (PRE), immediately post exercise (IP), 15 minutes post exercise (P15), and 30 minutes post exercise (P30). The catheter remained in the vein for the duration of the session and was kept patent with sterile saline. Following the insertion of the catheter, the PRE blood

sample was obtained and the participant performed the dynamic warm-up described under Session 1. Immediately thereafter, the participant began the exercise protocol.

Participants completed 12 consecutive rounds of kettlebell swing exercise with each round consisting of 30 seconds of exercise followed by 30 seconds of rest. Investigators provided verbal encouragement to the participant to complete as many swings in the 12 minute period as possible. The number of repetitions performed in each round was counted using a handheld counting device (Fisher Scientific, Pittsburgh, PA) and recorded. Immediately following the completion of the exercise protocol, the participant was seated and the IP blood sample was obtained. The participant remained seated comfortably for the remainder of the session, including during the collection of the P15 and P30 blood samples. Heart rate (HR) was measured before exercise and at the end of each 30 second round of swings (e.g., immediately after participant set the kettlebell down on the ground) via telemetry using a heart rate monitor (Polar, Lake Success, NY). A rating of perceived exertion (RPE) was obtained using Borg's 6-20 category scale before exercise and at the end of each 30 second round (Borg, 1970).

Experimental controls for Session 2. Participants refrained from: 1) eating or drinking anything (except for water) during the 12 hours leading up to the KST, 2) any alcohol ingestion for 48 hours prior to the KST, 3) consuming large amounts of caffeine on test day, 4) engaging in sexual activity for 24 hours prior the KST, and 5) performing any resistance exercise or intense aerobic exercise for 72 hours prior to the KST. Additionally, participants were asked to drink 0.5-1 liter of water the night before the KST to help ensure adequate hydration upon arrival at the laboratory. The participants were instructed to continue with regular sleeping habits as much as possible prior to the KST.

Biochemical analyses. Serum samples were allowed to clot at room temperature. Samples were then centrifuged at 1,500 g for 15 min at 4 °C and the resultant serum and plasma were aliquoted and stored at -80 °C until analysis. Samples were analyzed in duplicate for T, GH, C, and myoglobin using commercially available enzyme-linked immunosorbent assays (Alpco, Salem, NH). Assay sensitivity was 0.076 nmol·l⁻¹, 0.5 ng·ml⁻¹, 0.4 µg·ml⁻¹, and 6.25 ng·ml⁻¹, and intra-assay variances were 3.4%, 8.1%, 4.5%, and 5.0% for T, GH, C, and myoglobin, respectively. Automated analyzers were used to measure hemoglobin (Hb201, HemoCue AB, Angelholm, Sweden) and lactate (Lactate Plus, Nova Biomedical, Waltham, MA) concentrations. Creatine kinase concentrations (PRE: 184.0 ±77.5 IU·L) were also measured using an automated analyzer (Chemwell-T, Awareness Technology, Palm City, FL) for PRE blood samples to help determine the extent of recent muscle damage. Hart et al. (Hart, Drevets, Alford, Salacinski, & Hunt, 2013) have previously validated the Lactate Plus analyzer against a standard bench top method. Hematocrit was measured using standard micro-capillary tube centrifugation technique. Plasma volume shifts were calculated from hemoglobin and hematocrit values using the methods of Dill and Costill (Dill & Costill, 1974). Plasma volume was reduced at IP (-11.5% ± 6.6%) and returned to PRE values at P15. Circulating biomarker concentrations were not adjusted for plasma volume shift.

Statistical Analyses

Data were analyzed using one-way ANOVAs with repeated measures on time (IBM SPSS Statistics version 20, Chicago, IL). Fisher's least significant difference *post hoc* test was used to determine pairwise differences where appropriate. The alpha level was set at $p \leq 0.05$. Data are presented as mean ± standard deviation (SD) unless otherwise noted.

RESULTS

Participants completed a total of 227 ± 23 swings for an average of 19 ± 2 swings per 30 second round. The number of swings per round did not change significantly during the exercise bout. The HR and RPE data are presented in Table 1. Following each round of swings, HR and RPE were significantly increased ($p \leq 0.05$) compared to the previous round (or PRE) and thus peaked for the final round of swings. The HR averaged across all rounds was 157 ± 13 beats·min⁻¹ ($80.0 \pm 7.3\%$ of age predicted HRmax [$220 - \text{age}$]). Blood lactate concentrations (PRE: 1.1 ± 0.5 ; IP: 7.0 ± 3.0 ; P15: 4.0 ± 2.7 ; P30: 2.5 ± 1.8 mmol·l⁻¹) were significantly increased at each time point compared to PRE; blood lactate concentrations at P15 were significantly decreased as compared to IP. Similarly, blood lactate concentrations at P30 were significantly decreased as compared to P15.

Table 1

Heart Rate and RPE Immediately Following Each Round of Kettlebell Swings and Mean Number of Swings per Round

	Rest	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12
HR	57±1 2 ^a	132± 15 ^b	146± 15 ^c	149± 16 ^d	154± 15 ^e	155± 17 ^e	158± 16 ^f	161± 15 ^{g, h}	162± 13 ^g	164± 12 ^h	166± 11 ⁱ	168± 11 ^j	170± 10 ^k
RPE		10.4± 1.6 ^a	11.8± 1.8 ^b	12.5± 1.5 ^c	13.5± 2.0 ^d	14.2± 2.0 ^e	14.7± 2.2 ^f	15.3± 1.9 ^g	16.0± 1.9 ^h	16.6± 1.9 ⁱ	17.1± 2.0 ^j	17.5± 2.1 ^k	18.3± 1.9 ^l
SWINGS		19±2	19±2	19±2	19±2	19±2	19±2	19±2	19±2	19±2	19±2	19±2	19±2

At rest and following rounds 1-12 (R1-12). Means with different superscripts are significantly ($p \leq 0.05$) different. Data presented as Mean ±SD.

Results for T concentrations are shown in Figure 1. Compared to PRE, T concentrations were significantly increased ($p \leq 0.05$) at IP. The T concentrations were significantly decreased

at P15 and P30 compared to IP; T concentrations at P15 were significantly increased compared to P30.

Figure 1. Testosterone concentrations prior to exercise (PRE), immediately post exercise (IP), and 15 (P15) and 30 (P30) minutes post exercise. Means with different superscripts are significantly ($p \leq 0.05$) different. Data presented as Mean $\pm$ SE.

Results for GH concentrations are shown in Figure 2. Compared to PRE, GH concentrations were significantly increased at IP, P15, and P30. The GH concentrations did not differ among IP, P15, and P30.

Figure 2. Human Growth Hormone concentrations prior to exercise (PRE), immediately post exercise (IP), and 15 (P15) and 30 (P30) minutes post exercise. Means with different superscripts are significantly ($p \leq 0.05$) different. Data presented as Mean $\pm$ SE.

Results for C concentrations are shown in figure 3. Compared to PRE, C concentrations were significantly increased at IP and P15. C concentrations did not differ between IP and P15. C concentrations at P30 were significantly decreased compared to IP and P15.

Figure 3. Cortisol concentrations prior to exercise (PRE), immediately post exercise (IP), and 15 (P15) and 30 (P30) minutes post exercise. Means with different superscripts are significantly ($p \leq 0.05$) different. Data presented as Mean $\pm$ SE.

Compared to PRE, myoglobin concentrations (PRE: 17.8 ± 6.2 ; IP: 24.7 ± 7.0 ; P15: 24.3 ± 7.4 ; P30: $26.9 \pm 5.6 \text{ ng} \cdot \text{ml}^{-1}$) were significantly increased at IP, P15, and P30. Myoglobin concentrations at IP and P15 were not different; at P30, myoglobin concentrations were significantly increased as compared to P15, but not IP.

DISCUSSION

This is the first study to examine the acute hormonal response to the kettlebell swing exercise and it provides unique physiological insight into this exercise mode. The major finding of this study was that T, GH, and C concentrations were elevated immediately following the kettlebell exercise bout (12 rounds of 30 seconds of swings). Furthermore, measures of metabolic demand (HR, RPE, and lactate concentrations) were increased over the course of the kettlebell exercise bout. It appears that the kettlebell swing exercise, even when performed for a relatively short duration (11.5 min total, 6 min of exercise and 5.5 min of rest), can induce a significant neuroendocrine response. Since no previous study has investigated the endocrine response to kettlebell exercise, direct comparisons to prior research on the response to exercise mode is not possible. Kettlebell training has been shown to produce neuromuscular training adaptations similar, though lower in magnitude, to those found with traditional resistance training (Manocchia et al., in press; Otto et al., 2012); thus, we will make comparisons between the findings of the present study and the acute endocrine responses to resistance exercise.

Testosterone is a potent anabolic-androgenic hormone, which, among other biological effects, stimulates muscle protein synthesis and inhibits protein degradation (Demling & Orgill, 2000; Murras et al., 1998). Testosterone deficiency in young men has been associated with decreased strength (Murras et al., 1998) and reductions in strength outcomes from resistance training (Kvorning et al., 2006), while supraphysiologic doses of T have been associated with increased muscle strength and hypertrophy (Bhasin et al., 1996). Serum T concentrations increase acutely in men following resistance exercise of sufficient intensity and volume. Additionally, resistance exercises utilizing greater quantities of muscle mass induce greater acute increases in T concentrations following exercise. The external resistance used in the present

study (16kg) is much less than that used in traditional lower-body free weight resistance exercise, but the kettlebell swing still includes substantial muscle mass activation (i.e., gluteal, hamstring, and back extensor muscles) (McGill & Marshall, 2012). This muscle activation appears to provide sufficient stimulus to induce a post-exercise increase in serum T concentrations. Consistent with previous findings for resistance exercise, serum T concentrations were significantly increased immediately following the kettlebell exercise bout. The magnitude of post exercise increase in T concentrations was similar to that found in some previous studies on free weight resistance exercise (Hansen et al., 2001; Linnamo et al., 2005; Ronnestad et al., 2011); however, the duration of the increase was shorter than found in some studies (Hansen et al., 2001; Kraemer et al., 1998). The cause of this shorter duration for the elevation in testosterone concentration is not known, but could be due, at least in part, to plasma volume shift. Regardless of the cause, this study shows for the first time that a bout of kettlebell exercise can significantly increase circulating T.

Human GH is a large family of polypeptides that support a variety of physiological functions (including musculoskeletal development) and its concentration increases acutely in response to the metabolic demands of exercise. Though it is thought that there are more than 100 GH isoforms in circulation (Baumann, 1991), most studies (present study included) investigate the 22 kDa isoform, the principal and most abundant isoform of GH (Baumann, 2009). It has been previously suggested that the anterior pituitary secretes GH in response to the decreased blood pH associated with the anaerobic metabolism that results in high blood lactate concentrations following intense exercise (Elias, Wilson, Naqvi, & Pandian, 1997; Godfrey, Whyte, Buckley, & Quinlivan, 2009). Consistent with previous findings for the acute GH response to intense resistance exercise (Hakkinen & Pakarinen, 1993; Linnamo et al., 2005),

serum GH was elevated immediately following the kettlebell exercise bout. Lactate concentrations were also elevated post exercise. Though significant, the magnitude of increase in GH was relatively small in comparison with findings for heavy resistance exercise protocols. Smilios et al. (2003) compared the acute hormonal response of different resistance exercise protocols and found the greatest magnitude of increase in GH and lactate concentrations with 4 sets of 15 repetitions at 60% of 1RM and the smallest magnitude of increase with 2, 4 or 6 sets of 5 repetitions at 88% of 1RM. Results for GH and lactate concentrations in the present study are most similar in magnitude to the groups completing sets of 5 repetitions in their study. Additionally, Ghanbari-Niaki and et al. (Ghanbari-Niaki, Nabatchian, & Hedayati, 2007) examined the GH response to circuit resistance exercise in recreationally trained college men. Using a 16 minute full-body circuit training protocol (10 exercises at 35% of 1RM, 20s for each exercise, 1 min rest between circuits), they found a significant increase in GH lasting through the 30 minute post-exercise period. In the present study, GH concentrations following exercise were similar in pattern yet lower in magnitude than that found by Ghanbari-Niaki et al. The lower GH response found in the present study is likely due to the lower anaerobic metabolic demand compared to that of studies using traditional free weight exercise, as evident by the smaller peak circulating lactate concentrations ($7.0 \pm 3.0 \text{ mmol}\cdot\text{l}^{-1}$) for the kettlebell exercise bout.

Released from the adrenal cortex in response to stressors such as resistance exercise, C has potent anti-inflammatory, lipolytic, and catabolic effects. In muscle, C inhibits protein synthesis by inhibiting p70 S6K as well as androgen receptor signaling and thus modulates muscle metabolism (Shah, Kimball, & Jefferson, 2000). Similar to T and GH, C increases acutely following a bout of heavy resistance exercise in relation to the total volume and relative intensity of work performed. In agreement with previous studies (Hakkinen & Pakarinen, 1993;

Smilios et al., 2003), C was elevated immediately following the kettlebell swing exercise. However, C returned to PRE concentrations by P30, which is in contrast to other studies using high intensity resistance exercise protocols where C remained elevated at 30 minutes post exercise; additionally, the magnitude of the increase in C concentrations was lower in the present study (Ahtiainen et al., 2005; Kraemer et al., 1998). Again, this smaller hormonal increase is likely due to the lower metabolic demand during the kettlebell exercise.

Although no previous study has examined the hormonal response to kettlebell exercise, several studies have investigated the HR response to this exercise mode and thus allow for direct comparison with the HR findings of the current study. The kettlebell swing exercise protocol used in this study was similar to the protocol used by Farrar et al (Farrar et al., 2010). In their study, 10 college aged men performed as many kettlebell swings as possible in a 12 minute period at a self-determined pace, resting only as needed; the authors reported 265 ± 68 swings total and an average swing rate of 22 ± 6 swings $\cdot$ min⁻¹. Additionally, they reported 165 ± 13 bt $\cdot$ min⁻¹ and $86.0 \pm 6.0\%$ for average HR and percentage of age-predicted HR max (%HRmax), respectively. By comparison, we reported a total of 227 ± 23 swings and an average work rate of 19 ± 2 swings per 30 second round (or per minute if also considering the 30 second rest period) and 157 ± 13 for HR and $80.0 \pm 7.3\%$ of age-predicted HRmax, respectively. The inclusion of a 30 second rest period in every minute appears to have only marginally affected total work, work rate, HR, and %HRMax for the exercise bout. Hulsey et al. (Hulsey et al., 2012) later investigated the kettlebell swing exercise using a 10 minute swing protocol with each round comprised of 35 seconds of work and 25 seconds of rest. The authors reported average HR and %HRmax of 177 ± 11 bt $\cdot$ min⁻¹ and $89.1 \pm 5.3\%$, respectively, which was notably higher than in the present study. However, in the study by Hulsey et al. (Hulsey et al., 2012), HR data from the

first 4 minutes were not included (only HR data at minutes 5, 7, 9, and 10 were reported); since HR in the present study increased across the 12 rounds of swings it is likely that this exclusion of HR data for the first 4 minutes of exercise inflated their reported average HR and %HRMax. Additionally, their protocol included 5 seconds more of exercise and 5 seconds less of rest compared to the present study. Thus, although the average number of swings per round was not reported, the additional exercise time combined with abbreviated rest periods might also help explain the higher HR and %HRMax.

In summary, musculoskeletal adaptations are modulated by the hormonal milieu and the acute hormonal response to resistance exercise is important in the design of resistance training programs. The results of this study show that the kettlebell swing exercise can induce a significant neuroendocrine response, as T, GH, and C concentrations were elevated immediately following the 12 rounds of kettlebell swings. Though the kettlebell swing exercise produced a significant increase in all hormones measured, the magnitude and duration of the increase was smaller than that commonly observed with heavy lower-body resistance exercise protocols. However, because T and GH are important in the development of strength and muscular growth, it is possible that the acute hormonal response to the kettlebell swing exercise can aid improvements in strength and muscle mass. Thus, due to the neuroendocrine response and considerable metabolic demand (reflected by HR and RPE) elicited, the kettlebell swing exercise might be a useful tool for inclusion in a resistance exercise program

PRACTICAL APPLICATIONS

The kettlebell swing exercise is a ballistic, full body type exercise that, if performed over time (training), can increase muscle strength and size (hypertrophy) as well as cardiovascular endurance and thus provides a somewhat unique physiological stimulus. The increases in strength and muscle size are likely due, at least in part, to the significant neuroendocrine response induced by this exercise mode. Although in isolation, traditional weightlifting training programs are likely to produce greater increases in maximal strength and hypertrophy, the addition of kettlebell swing exercise to such programs might augment the outcomes through additional acute increase in important neuroendocrine factors, especially if implemented on days for which the traditional training does not induce a substantial hormonal response (e.g., “off days” or “low repetition-long rest days”). In conclusion, the strength and conditioning professional might find this kettlebell exercise to be a useful tool in the toolbox for athletic development.

APPENDIX A
IRB CONSENT FORM

University of North Texas Institutional Review Board

Informed Consent Form

Before agreeing to participate in this research study, it is important that you read and understand the following explanation of the purpose, benefits and risks of the study and how it will be conducted.

Title of Study: Hormonal Response to two different Kettlebell training protocols

Principal Investigator: Jakob Vingren Ph.D., University of North Texas (UNT) Department of Kinesiology, Health Promotion and Recreation.

Purpose of the Study: You are being asked to participate in a research study which involves testing the effects of two different kettlebell exercise protocols on hormonal response.

Study Procedures: Before you can be approved for participation you must complete a medical history, nutrition & physical activity questionnaire, to ensure that you meet all the inclusion and none of the exclusion criteria.

Inclusion/exclusion criteria:

Inclusion: To meet inclusion criteria you must be: 1) male between the ages of 18-40 years; and 2) resistance trained for at least 3 months (training at least twice a week).

Exclusion: Upon review of your medical history form (using attached medical questionnaire) we will exclude you if a pre-existing orthopedic limitations or medical condition may put you at risk during strength testing exercises. Such criteria will include, but may not be limited to, heart conditions or anomalies, respiratory conditions, blood pressure problems, musculoskeletal problems or previous orthopedic injuries that would limit the range of motion about the hip, knee or ankle joint. Special attention will be given to exclude potential volunteers with lower back problems including herniated inter-vertebral discs. You cannot participate in this study if you have recently taken, currently take, or plan to take any hormonal substances such as testosterone, anabolic steroids, and growth hormone. In addition if you have recently used (within the last 3 months) or currently use recreational drugs, tobacco products, or any hormonal medication you will be excluded from participation due to the potential interference with the outcome of the study. You will also be excluded if you currently or recently have used nutritional supplements, or adhered to an atypical diet that might confound the results of this study. We will reserve the right to dismiss you at any time if we believe you do not follow the instructions provided for this study.

Study overview:

You will be asked to complete two familiarization visits and two exercise protocols. This is a total of four visits. Each visit should take about an hour. During the familiarization visits, you will be shown the proper technique for completing the kettlebell swing exercise. After a warm-up, you will practice the kettlebell swing exercise and learn proper technique. For the two exercise protocol visits, you will perform: either 12 minutes of continuous kettlebell swings (working at your own pace while attempting to maintain a steady rhythm), or 12 rounds of 30 seconds of swings with 30 seconds of rest. In both protocols, you will attempt to complete as many swings as possible. The order of these protocols will be random and you will not know which protocol you will be performing on the first visit. You will perform the other exercise on the next visit. For example, if you perform 12 minutes of continuous swings on the first exercise

protocol visit, then you would perform 12 rounds of 30 seconds of swings with 30 seconds of rest on the following visit.

On both exercise protocol visits (visits 3 and 4), you will report to the laboratory in the morning after a twelve hour overnight fast. Before the testing begins, an IV catheter will be inserted into a forearm vein. The catheter will remain in for the duration of each session and blood will be drawn prior to testing, immediately after testing, and fifteen and thirty minutes into recovery from exercise.

Visits:

Session 1 and 2: Anthropometric measurements and familiarization.

In session 1, you will report to the Applied Physiology Laboratories (APL) (PEB 111) so that we can teach you correct technique for performing the kettlebell swing. Prior to learning and practicing the kettlebell swing, we will measure your height, weight, and body composition using the dual-energy X-ray absorptiometry (DXA) machine take you through a dynamic warm-up. Forty-eight hours after session 1, you will return for session 2 in order to practice the kettlebell swing and ensure you understand how to pace yourself during the exercise protocol.

Session 3 and 4: Kettlebell Swing Testing.

All visits:

Each visit in this study will be separated by at least one week. You will report to the APL and a needle will be inserted into a forearm vein, the needle is then removed leaving behind a thin plastic tube (similar to an IV). Then a pre-exercise blood sample will be collected. You will then perform a warm-up using dynamic stretches (e.g., heel kicks, lunges).

Using a 16kg (35lb) kettlebell, you will complete either 12 minutes of continuous kettlebell swings (working at your own pace while attempting to maintain a steady rhythm), or 12 rounds of 30 seconds of swings with 30 seconds of rest. Immediately after you have completed the exercise protocol, a blood sample will be obtained. You will then rest in a comfortable chair (resting, reading, or watching material that will not evoke heavy emotions). Blood will be drawn 15 and 30 min into recovery from exercise. Rating of perceived exertion (RPE) and heart rate will be assessed throughout and following exercise.

Specific Procedures:

Heart rate and Rating of perceived exertion:

You will be asked to wear a standard heart rate monitor during the 2 protocol visits. You will be asked to rate how hard you were working (what your exertion was) on a scale from 6 to 20.

Body composition testing: You will receive a scan using the dual-energy X-ray absorptiometry (DXA) machine. This test will determine your percent body fatness and also your bone mineral density. For this test, you will remove your shoes and any metal objects (like belt buckles, zippers, and jewelry). You will lie still on a table for about 15 minutes. A mechanical “arm” will move slowly from over your head to over your toes.

Blood draws: For each blood draw, ~20 ml of blood will be collected (about 1 table spoon). For each of the 2 protocol visits a total of about 80 ml of blood will be collected. Although this blood volume is replenished almost immediately we ask that as a safety precaution, you refrain from donating blood within the time period two weeks before the start of the study through four weeks after the end of the study. The blood samples will be analyzed for testosterone, growth hormone, cortisol, lactate, and hemoglobin concentration as well as hematocrit.

Diet: You will be provided diet logs to record everything that you eat and drink during the 3 days preceding the first of the 2 experimental protocol visit (including the day of the visit). You will then be provided a copy of this log and asked to replicate it for the remaining protocol visit. Additionally, you must drink at least 0.5 liter of water the night before and the morning of the experimental trials to ensure adequate hydration. Hydration state will be determined from a small urine sample you will provide. If you are not hydrated you will be asked to drink additional water.

Other instructions and restrictions: All experimental trials will be performed at the same time of day. From 3 days before each visit you must refrain from resistance or exhaustive exercise, alcohol, and high doses of caffeine (more than 1 cup of coffee per day). You must refrain from engaging in sexual activities for 24 hours before each protocol (visits 3-4) as this can affect the variables measured in this study.

Your total time commitment is approximately 4 hours: four 1-hour visits.

Foreseeable Risks: The potential risks involved in this study are as follows:

Resistance Exercise: The performance of muscular exercise and physical effort can entail the potential hazards of injury from over-exertion and/or accident. This study will be planned to avoid injury to the musculoskeletal system. The possibility of cardiopulmonary overexertion is slight and will be minimized by screening, selection and monitoring procedures that are designed to anticipate and exclude the rare individual for whom exercise might be harmful. It is questionable whether it is possible to overexert the heart by voluntary exercise unless there is some underlying disease. Nevertheless, there are a number of disorders, some of which can readily escape clinical detection, where strenuous exercise may be potentially hazardous or may precipitate disability. Some of these, such as intracranial aneurysms or solitary pulmonary cysts or alveolar blebs, are rare and not readily diagnosed in the absence of symptoms; for these a history of tolerance to prior strenuous exercise must suffice. For other conditions, which might be more common, such as ischemic heart disease, the striking age-related incidence and the association of several identifiable risk factors with latent disease provides a rationale for a directed screening of certain participant candidates.

Performing lower-body resistance exercises such as the kettlebell swing may cause back pain and, in rare instances, back injury. During this type of testing, transient episodes of lightheadedness, chest discomfort, irregular heartbeats, abnormal blood pressure responses, and/or leg cramping may occur. The risk of heart attack, although small, (approximately 1 occurrence in 15,000 tests) does exist. The chance of any of these events occurring will be minimized by our screening, selection and monitoring procedures, and by the use of properly conducted research procedures. Laboratory personnel involved in the testing are currently certified in CPR and we have emergency procedures in place for the rare event of an injury or heart attack. Additional risks associated with resistance exercise and with the strength and power tests and training involve the possibility of muscle strains or pulls of the involved musculature, delayed muscle soreness 24 to 48 hours after exercise, muscle spasm, and in extremely rare instances, muscle tears. Such risks are very low. Every effort will be made to make this investigation safe for the participant through familiarization, experienced personnel, warm-up and cool-down (i.e., stretching and low intensity activity-specific exercise), technique instruction and practice, supervision, screening, monitoring and individualized exercise testing. All of these factors, including those previously outlined, should dramatically contribute to a reduction, if not an elimination, of any potential risks associated with this study.

The Principal Investigator (Dr. Jakob Vingren) is a National Strength and Conditioning Association (NSCA) Certified Strength and Conditioning Specialist recertified with Distinction.

Blood Draws: We will take blood samples from a small needle which will be inserted in a vein in your arm. There will be discomfort when the needle initially punctures your skin. While blood draws are normally a safe procedure, it is possible that short-term side effects can occur, such as dizziness, bruising, or fainting. Although the chances are remote, it is also possible that bruising around the vein, an infection, or nerve damage can develop. All possible precautions to avoid infection will be taken including use of sterile disposable needles, drapes and gauze and the practice of sterile techniques during blood sampling. All blood samples will be obtained by a person trained in drawing blood who will use standard laboratory operating procedures. In case of emergency, we will call 911.

Body Composition: You will be exposed to a very small amount of radiation by the scanner used to measure your body composition. Exposure to any amount of radiation, no matter how low, may cause abnormal changes in cells. However, the body continuously repairs these changes and the amount of radiation is very low in this study. The total exposure for a whole body scan is approximately 125 times less than the average radiation from a standard chest x-ray or 150 times less than a round trip transcontinental flight. Thus, the radiation levels are extremely low and the health risk minimal. The scan will be performed by a technician who has received training required by the State of Texas for operating the scanner. You will complete a separate “Acknowledgement of risk” form for the scan as well as a safety questionnaire prior to any scan to ensure you are not at increased risk during the scan.

Benefits to the Participants or Others: There is limited direct benefit to you for participating in this study; however, all your data will be explained to you and interpreted for you so that a maximum amount of educational understanding and use of the data will be achieved. Participation in this study will also afford you instruction in correct weight-lifting techniques and you will learn your endocrine and physical response to resistance exercise. You will also learn your body composition and bone density values. The results could help researchers better understand the hormonal response to resistance exercise and help in the prescription of resistance exercise.

Compensation for Participants: There will be no compensation for this study.

Procedures for Maintaining Confidentiality of Research Records: All data will be kept in coded participant files in the primary investigator's locked files. Participant codes will be used when statistical analyses are performed or when experimental feedback sheets are provided to you. All investigators, professional staff, and technicians are aware of the confidentiality involved with this study and have completed the confidentiality training required by the University. Your data will not be available or divulged to anyone outside of the experimental research team. The data files will be kept for 3 years after the study is terminated. The confidentiality of your individual information will be maintained in any publications or presentations regarding this study.

Questions about the Study: If you have any questions about the study, you may contact Dr. Jakob Vingren at telephone number (940) 565 3899.

Review for the Protection of Participants: This research study has been reviewed and approved by the UNT Institutional Review Board (IRB). The UNT IRB can be contacted at (940) 565-3940 with any questions regarding the rights of research participants.

Research Participants' Rights: Your signature below indicates that you have read or have had read to you all of the above and that you confirm all of the following:

- Dr. Jakob Vingren or another researcher has explained the study to you and answered all of your questions. You have been told the possible benefits and the potential risks and/or discomforts of the study.

- You understand that you do not have to take part in this study, and your refusal to participate or your decision to withdraw will involve no penalty or loss of rights or benefits. The study personnel may choose to stop your participation at any time.
- You understand why the study is being conducted and how it will be performed.
- You understand your rights as a research participant and you voluntarily consent to participate in this study.
- You have been told you will receive a copy of this form.

Printed Name of Participant

Signature of Participant

Date

For the Principal Investigator or Designee:

I certify that I have reviewed the contents of this form with the participant signing above. I have explained the possible benefits and the potential risks and/or discomforts of the study. It is my opinion that the participant understood the explanation.

Signature of Principal Investigator or Designee

Date

APPENDIX B
VISIT 1 CHECKLIST

Hormonal Response to Kettlebell Swings

Visit 1 Checklist

Participant name:

Participant ID:

Date of Birth:

Date:

REQUIRED PAPERWORK

Informed consent read, discussed, and signed:	Yes [☐]	No [☐]
Medical History Questionnaire completed:	Yes [☐]	No [☐]
Eligible for study:	Yes [☐]	No [☐]

BODY COMPOSITION

Height:

Body Mass:

DEXA Scan completed:	Yes [☐]	No [☐]
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FAMILIARIZATION SESSION

Dynamic warmup

Lying knee to chest pull	Yes [☐]	No [☐]
Lying straight leg raise	Yes [☐]	No [☐]
Quadruped scapulae retraction/protraction	Yes [☐]	No [☐]
Quadruped thoracic rotations	Yes [☐]	No [☐]
Quadruped hip circles	Yes [☐]	No [☐]
Walking lunges with hip flexor stretch	Yes [☐]	No [☐]
Lying hip abduction/external rotations	Yes [☐]	No [☐]
Glute bridges	Yes [☐]	No [☐]

Kettlebell Swings

Safety procedures	Yes [☐]	No [☐]
Kettlebell swing technique	Yes [☐]	No [☐]
Exercise protocol discussed	Yes [☐]	No [☐]
Practice swings session	Yes [☐]	No [☐]

SECOND VISIT INFORMATION

Protocols discussed:	Yes [☐]	No [☐]
Overnight fast discussed:	Yes [☐]	No [☐]
Questions answered:	Yes [☐]	No [☐]
Date scheduled:	Yes [☐]	No [☐]

APPENDIX C

KETTLEBELL SWING DATA COLLECTION SHEET

Kettlebell Swing Data Sheet				
Participant ID:				
Date:			Arrival time:	
Height:	cm			
Body mass:	kg			
Sleep:	hours			
Overnight fast?		Yes () No ()		
Urine Specific Gravity:				
Provided water?		Yes () No ()		
Pre-exercise soreness:			HR Monitor #:	
PRE time:			PRE HR:	
Dynamic Warmup completed		Yes () No ()		
Exercise time started:			Start HR:	
Round	Time	Heart rate	RPE	Number of Swings
Round 1	0:00 - 0:59			
Round 2	1:00 - 1:59			
Round 3	2:00 - 2:59			
Round 4	3:00 - 3:59			
Round 5	4:00 - 4:59			
Round 6	5:00 - 5:59			
Round 7	6:00 - 6:59			
Round 8	7:00 - 7:59			
Round 9	8:00 - 8:59			
Round 10	9:00 - 9:59			
Round 11	10:00 - 10:59			
Round 12	11:00 - 11:59			
Exercise Complete Time:		Total Number of Swings:		
Total Number of Swings:				
IP time:				
+15 time:				
+30 time:				
Post-exercise (+30min) soreness:				
Completion time:				
Notes:				

Dynamic Warmup				
Exercise		Reps		Completed
Lying Knee to Chest pull		8 each side		[]
Lying straight leg raise		8 each side		[]
Quadruped scapulae protraction/retraction		10		[]
quadruped thoracic rotations		8 each side		[]
Quadruped Hip circles		10 each side		[]
Walking lunges with hip flexor stretch		10 each leg		[]
Lying hip abduction/external rotations		10 each side		[]
Glute bridges		15		[]

APPENDIX D

BLOOD SAMPLE HB, LACTATE, AND HCT

Blood Draws and Processing Sheet

Date: _____ **Subject:** _____ **Visit#:** _____

Cannula insertion time: _____ Location: _____

	Time	Initial	Hb1	Hb2	Lac1	Lac 2	Hct1	Hct2	Hct3
Pre									
IP									
+15									
+30									

Samples aliquoted into time periods?: **Yes:** _____

Samples transferred to -80° Freezer? **Yes:** _____

APPENDIX E

HORMONE ANALYSIS SHEET

Analyte: _____ Study: _____ Date: _____ Technician _____

	1	2	3	4	5	6	7	8	9	10	11	12
A												
B												
C												
D												
E												
F												
G												
H												

Incubation 1 start time: _____ Incubation 2 start time: _____ Incubation 3 start time: _____

Comments:

APPENDIX F
MEDICAL HISTORY QUESTIONNAIRE

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