# A TEMPORAL AND KINETIC COMPARISON OF THE KETTLEBELL SWING AND MAXIMAL VERTICAL JUMP

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The purpose of this study was to compare the temporal and kinetic characteristics of the kettlebell swing to those of the maximal vertical jump in an attempt to understand how the kettlebell swing could potentially enhance vertical jump performance from the kinetic perspective. Twenty-five recreational athletes completed five two-handed kettlebell swings and 5 maximal vertical jumps while ground reaction force data was sampled at 1200 Hz using two force plates. Variables related to power such as time to peak rate of force development (RFD), peak RFD, and average RFD were smaller in the kettlebell swing than the vertical jump. The lack of similarity between the kettlebell swing and vertical jump indicates the kettlebell swing may not be an appropriate training method for eliciting improvements in vertical jump performance at the 20% body weight load examined in this study.

**KEYWORDS**: ground reaction force, rate of force development, time to peak force, training

**INTRODUCTION:** In recent years, kettlebell exercises have regained popularity across a broad spectrum of exercising populations. One likely reason for the resurgence in kettlebell exercise popularity is that these whole body exercises are not very technical, thus making them relatively easy to learn. This is especially true when kettlebell exercises are compared with other whole body resistance training methods such as Olympic lifts. This fact makes lifts like the kettlebell swing appealing to both athletes and recreationally active individuals alike. In addition to their relative simplicity, many strength and conditioning professionals who encourage the use of kettlebell exercises believe they provide improvements in muscular strength, endurance, and power simultaneously, making them an even more attractive method of training. At present, evidence to support such claims is somewhat limited. Furthermore, existing research related to kettlebell exercises and training has largely ignored women and the benefits that they may receive from completing such exercises (Lake & Lauder, 2012a; Lake & Lauder, 2012b).

Existing research has provided much important information regarding kettlebell exercises despite ignoring potential sex differences in the performance and benefits of these exercises. For example, previous work indicates that kettlebell training can improve maximal and explosive strength in men (Lake & Lauder, 2012a). Similarly, improvements in strength and power were observed during a 10-week kettlebell training program among men and women (Monacchia, Spierer, Lufkin, Minicheiello, & Castro, 2013). However, the influence of kettlebell training on vertical jump height remains unclear (Jay, et al., 2013; Monacchia, et al., 2013). At present, findings in the literature do not consistently support the claims of all the proposed benefits of kettlebell training. Furthermore, because previous researchers have averaged dependent variables across sexes it is unclear if men and women are performing these exercises in a similar manner or experiencing the same benefits (Jay et al., 2013; Monacchia, et al., 2013). Based on existing vertical jump literature it is likely that sex differences do exist in the performance of these exercises (Laffaye, Wagner, & Tombleson, 2014).

In order to better understand the somewhat mixed results of previous research it is useful to examine the biomechanics of the kettlebell swing. Therefore, the purpose of the present study was to compare the temporal and kinetic characteristics of the kettlebell swing and vertical jump in recreationally active men and women. With the intent of examining the specificity of the kettlebell swing as a training method for improving vertical jump performance. It was hypothesized that both the temporal and kinetic characteristics of the kettlebell swing and maximal vertical jump would be similar; however, it was believed that these effects would be dependent on sex. If the hypothesis is confirmed this would suggest that the kettlebell swing is an appropriate training modality for improving power as it relates to vertical jump performance.

**METHODS:** Fourteen women [age: 22 ± 6 years; height 1.71 ± 0.21 m; mass: 66.4 ± 9.2 kg] and eleven men [age: 23 ± 2 years; height 1.78 ± 0.05 m; mass: 78.3 ± 8.5 kg] volunteered and provided informed consent prior to participating in the present study. All participants were recreationally active individuals with formal training in kettlebell exercises, including the kettlebell swing. Study exclusion criteria included any self-reported history of injury that would make it difficult or painful to complete the kettlebell swing or maximal vertical jump.

To compare the temporal and kinetic characteristics of the kettlebell swing and vertical jump ground reaction force (GRF) data were collected during 3 tasks: (1) kettlebell swings, (2) countermovement vertical jumps, and (3) squat vertical jumps (data not presently reported). Two-handed kettlebell swings were completed with a weight equal to approximately 20% of the participants' body weight.

Upon finishing a health history questionnaire participants proceed to the warm-up which consisted of a 5-minute self-paced ride on a stationary bike followed by a series of dynamic warm-up exercises (e.g., high knees, walking lunges, etc.). After warming-up the subject continued on to three randomized blocks of trials: 5 kettlebell swing trials, 5 countermovement vertical jump trials, and 5 squat vertical jump trials. During each of the 5 kettlebell swing trials, participants were asked to perform 4 repetitions of the swing motion. For the countermovement vertical jumps participants were asked to perform the jumps at maximal effort with an arm swing. A minimum of 60 seconds rest was provided between all trials and blocks of trials.

GRF data were measured at 1200 Hz using two Kistler force plates (*Kistler Amhesrt, NY, USA*) interfaced with Bioware (3.24, *Kistler, Ameherst, NY, USA*) data acquisition software. GRF data were low-pass filtered using a $4^{th}$-order, zero-lag Butterworth filter at a cut-off frequency 10 Hz. Data were analyzed using a custom written MatLab (*The MathWorks, Inc., Natick, MA, USA*) program which allowed for analysis of the second repetition from each set of four kettlebell swings and the maximal vertical jumps. The velocity of the mover's center of mass was computed by subtracting system weight from the GRF data and then dividing by the mass of the system and integrating with respect to time (Dowling & Vamos, 1993). The start of the second kettlebell swing repetition was identified by finding the instant when the vertical velocity transitioned from positive to negative after the first peak GRF occurred.

The following variables were analyzed between the instants of the minimum and peak vertical GRF of the kettlebell swing and vertical jump, respectively: peak GRF, time to peak GRF, peak rate of force development (RFD), time to peak RFD, and average rate of force development (RFD). Time to peak GRF was computed as the time elapsed between the minimum and maximum GRF. Peak RFD was computed from the vertical GRF data using the first central difference method. Time to peak RFD was computed as the elapsed time between the minimum vertical GRF and the peak RFD. All values were normalized to system weight (i.e., body weight plus kettlebell weight for the kettlebell swings or body weight for the vertical jump). Values for each variable were averaged across trials of the same type. Effects of task and sex on the dependent variables were tested using a 2-way repeated-measures ANOVA. Significant interaction effects were explored using t-tests as appropriate. The alpha level was set at 0.05 for the ANOVA analyses and 0.025 for all post-hoc analyses.

**RESULTS AND DISCUSSION:** Independent of sex, participants exhibited a smaller time to peak RFD, a smaller peak RFD, and a smaller average RFD in the kettlebell swing compared with the vertical jump (Table 1). The peak RFD typically occurred during the unloading period of the respective tasks; it was expected that peak RFD would occur earlier in the kettlebell swing than the vertical jump to allow sufficient time to break the downward motion of the greater system weight during the kettlebell swing (Figure 1). With a lighter load it is possible that an individual could break later during the kettlebell swing thus exhibiting a temporal pattern that more closely resembles that of the vertical jump. The lower peak RFD and average RFD in the kettlebell swing indicates that the swing was being performed with less explosive strength than the vertical jump. The poor match in peak and average RFD between the kettlebell swing and vertical jump in the present study is troublesome as greater RFD has been previously associated with greater vertical jump height (McLellan, Lovell, & Gass, 2011; Dowling & Vamos, 1993). Thus, it seems that a kettlebell swing performed at 20% bodyweight may not elicit the RFD necessary to elicit improvements in vertical jump performance. This finding may help to explain discrepancies in the findings of Lake and Lauder (2012a) and Manocchia et al. (2013). That is, it is possible that Manocchia et al. (2013) did not observe improvements in vertical jump performance at the conclusion of their 10-week training program because the load used during the training program was not specific to the vertical jump. Regardless of previous findings, the present work highlights the importance of training specificity.

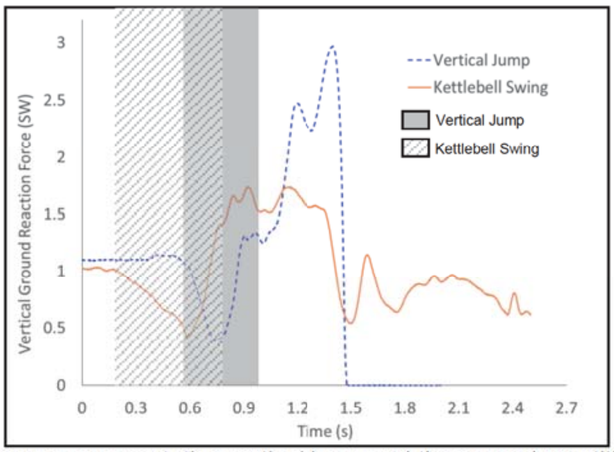


**Figure 1:** Vertical GRF from a representative vertical jump and the second repetition from a kettlebell swing trial. *Note*: SW = System Weight. Shaded area represents unloading period for each task.

**Table 1**
**Force- time variables as a function of task and sex (Mean ± SD)**

| Variable (units) | Men | | Women | |
|---|---|---|---|---|
| | Vertical Jump | Kettlebell Swing | Vertical Jump | Kettlebell Swing |
| **Peak GRF (SW)** | 2.59 ± 0.25 | 1.67 + 0.10* | 2.07 ± 0.30† | 1.55 ± 0.13*† |
| **Peak RFD (SW/s)** | 15.8 ± 4.23 | 9.96 ± 1.58* | 12.11 ± 4.86 | 10.72 ± 1.95* |
| **Average RFD (SW/s)** | 4.57 ± 2.86 | 1.11 ± 0.19* | 3.08 ± 2.12 | 1.16 ± 0.27* |
| **Time to Peak GRF (ms)** | 587 ± 174 | 568 ± 87 | 591 ± 186 | 551 ± 144 |
| **Time to Peak RFD (ms)** | 340 ± 139 | 194 ± 60* | 300 ± 192 | 142 ± 65* |

***Notes:*** SW = system weight (i.e., body weight or body weight plus kettlebell weight). *Significantly different from the vertical jump ($p$ < 0.001). †Significantly different from men ($p$ = 0.005).

The magnitude of the peak GRF was dependent on both task and sex. That is, the peak GRF was smaller in the kettlebell swing compared with the vertical jump and men exhibited a greater peak GRF than women in both tasks (Table 1). The greater peak GRF in the vertical jump may be simply due to the purpose of the performance. That is, participants were not trying to leave the ground during the kettlebell swing as they were during the vertical jump. Furthermore, a greater peak GRF in-itself does not assure greater vertical jump performance (Garhammer &

Gregor, 1992), thus this kinetic difference between the tasks may not be as relevant as the previously discussed differences in RFD between tasks. The sex difference in the magnitude of the peak GRF emphasizes the need to further examine the characteristics of sex differences in kettlebell swing and jump research.

Time to peak GRF was the only variable in the present study that did not differ as a function of task or sex (Table 1). This finding suggests that if we modify the kettlebell swing load, it is possible that other kettlebell swing temporal and kinetic variables may begin to better match those of the vertical jump.

The present results should be interpreted in light of the following cautions: (1) this study included recreational athletes, other populations may perform differently on these variables, (2) kettlebell swings were performed at a 20% body weight load, these findings may not hold true for kettlebell swings performed at different intensities, and (3) the effect of kettle swing exercises on coordination of the vertical jump was beyond the scope of this study. Despite these limitations, it appears that kettlebell swings performed at a 20% body weight load are not the most specific resistance training method for eliciting improvements in vertical jump performance in recreationally active men and women.

**CONCLUSIONS:** In the present study participants performed the kettlebell swing with less force and power (i.e., lower rate of force development) than the vertical jump. Based on these findings the kettlebell swing performed with a 20% body weight load is not an exercise with appropriate specificity for enhancing the explosive strength used in vertical jumping. Furthermore, though the recreationally active men and women in the present study did perform the kettlebell swings and vertical jumps with some similarity, the observed difference in peak GRF indicates the need for future researchers to be aware of the potential influence of sex when considering research methods and interpreting results related to kettlebell training and vertical jump performance. Because it is likely that people of all levels and abilities will continue to incorporate kettlebell exercises in their training programs, it is important that we continue to work to understand the effect of load and sex on the temporal and kinetic characteristics of the kettlebell swing.

**REFERENCES:**

Dowling, J.J & Vamos, L.V. (1993). Identification of kinetic and temporal factors related to vertical jump performance. *Journal of Applied Biomechanics, 9*, 95-110.

Garhammer J. & Gregor R. (1992). Propulsion forces as a function of intensity for weightlifting and vertical jumping. *Journal of Applied Sport Science Research, 6*, 129-134.

Jay, K., Jakobsen, M.D., Sundstrup, E., Skotte, J.H., Jorgensen, M.B., . . . (2013). Effects of kettlebell training on postural coordination and jump performance: A randomized controlled trial. *Journal of Strength and Conditioning Research, 27,* 1202-1209.

Laffaye, G., Wagner, P.P. & Tombleson, T.I. (2014). Countermovement jump height: gender and sport-specific difference in the force time variables. *The Journal of Strength & Conditioning Research, 28,* 1096-1105.

Lake, J.P. & Lauder, M.A. (2012a). Kettlebell swing training improves maximal and explosive strength. *Journal of Strength and Conditioning Research, 26*, 2228-2233.

Lake, J.P. & Lauder, M.A. (2012b). Mechanical demands of kettlebell swing exercise. *Journal of Strength and Conditioning Research, 26*, 3209-3216.

McLellan, C.P., Lovell, D.I., & Gass, G.C. (2011). The role of rate of force development on vertical jump performance. *Journal of Strength and Conditioning Research, 25,* 379-385.

Monacchia, P., Spierer, D.K., Lufkin, A.K.S., Minichiello, J., & Caster, J. (2013). Transference of kettlebell training to strength, power, and endurance. *Journal of Strength and Condition Research*, 27, 477-484.