Observational Study

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The influence of weightlifting belts and wrist straps on deadlift kinematics, time to complete a deadlift and rating of perceived exertion in male recreational weightlifters

An observational study

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Abstract

Both weightlifting belts and wrist straps are commonly used weightlifting training aids but their effects on deadlift kinematics and performance were still not known. This study examined the effects of weightlifting belts and wrist straps on the kinematics of the deadlift exercise, time to complete a deadlift and rating of perceived exertion (RPE) in male recreational weightlifters.

This study used a repeated-measures, within-subjects design. Twenty male healthy recreational weightlifters (mean age ± standard deviation = 23.1 ± 2.5 years) were recruited from 2 local gyms and the Education University of Hong Kong between January and April 2021. All participants used various combinations of belt and straps during a conventional deadlift. The hip and knee flexion, cervical lordosis, thoracic kyphosis and lumbar lordosis angles and time to complete a deadlift were measured using video analysis software. RPE was also recorded.

Wearing both a belt and wrist straps was found to reduce knee flexion angle ($P < .001$), but not hip flexion angle ($P > .05$), during the setup phase of the deadlift compared to wearing no aid. Wearing straps alone exaggerated thoracic kyphosis in the lockout phase of the deadlift compared to wearing a belt alone ($P < .001$). No changes were seen in cervical and lumbar lordosis angles when using any or both of the weightlifting aids. Additionally, the participants completed deadlifts faster when wearing both a belt and straps ($P = .008$) and perceived less exertion when wearing a belt and/or straps ($P < .001$).

Weightlifting belts and wrist straps, when using together, have positive effects on the kinematics of deadlift, time to complete a deadlift and RPE in male recreational weightlifters. Trainers should recommend the use of a belt and straps together, but not straps alone, to recreational weightlifters when performing deadlift training.

Abbreviations: 1RM = one-repetition maximum, n_p^2 = partial eta-squared, RPE = rating of perceived exertion.

Keywords: equipment and supplies and biomechanical phenomena, lifting, sports

1. Introduction

The deadlift is 1 of the 3 events performed in powerlifting competitions and is an exercise commonly prescribed for athletes to improve total body strength. However, lower back injury is very common among less-skilled recreational weightlifters as they tend to adopt a more stooped posture in the initial stages of the deadlift, leading to an elongated lever arm and placing more stress on the lower back.[1,2] It is widely acknowledged that use of a weightlifting belt can increase intra-abdominal pressure, stabilize the spine, decrease spinal compression and reduce the

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likelihood of spinal injuries during weightlifting training.[3–5] However, to the best of our knowledge, no study has investigated whether the use of a weightlifting belt can prevent the development of a stooped posture in recreational weightlifters in the initial stages of a deadlift.[1] Moreover, no study has investigated whether the use of a weightlifting belt can alter the spinal curvature adopted in the finishing position of a deadlift, despite some evidence suggesting that it can prevent spinal shrinkage[6] and affect lumbar spine kinematics during heavy lifting.[7] This is important as spinal curvature affects the stress placed on the facet joints and intervertebral discs, thereby altering the overall compressive strength experienced by the spine.[8] It has been hypothesized that use of weightlifting belts may reduce spinal curvature and thus exert a protective effect against spinal injuries.

Many studies have reported that weightlifters experienced a greater sense of support and believed that their lifting capacity increased when wearing a belt.[3,9] As such, we hypothesized that weightlifters may perceive less exertion and altered lifting velocity when wearing a belt.[10] The first aim of this study was therefore to investigate the effects of using a weightlifting belt on lower limb joint angles in the initial stages of a deadlift, spinal curvatures adopted in the finishing position, overall rating of perceived exertion (RPE) and total time to complete a deadlift in recreational weightlifters.

Another commonly used weightlifting training aid is a pair of wrist straps.[11] Strap use can enhance grip strength and may provide a psychological boost when lifting heavy weights.[12–14] However, such straps attach the weightlifter directly to the loaded bar and may thus alter lifting kinematics and have the potential to injure the athlete if not used safely.[14] To date, no studies have investigated the influence of using wrist straps on weightlifting kinematics. However, previous studies have revealed that using lifting straps during deadlift training could result in slower movement speed[15] and decreased perceived exertion.[13] Therefore, the second aim of this study was to investigate the effects of using wrist straps on lower limb joint angles and spinal curvatures during a deadlift, overall RPE and total time to complete a deadlift in recreational weightlifters. We hypothesized that using wrist straps may alter lower limb joint kinematics and spinal curvatures, reduce overall RPE and increase time to complete a deadlift. As both weightlifting belts and wrist straps may be used together, the third aim of this study was to examine the effect of these aids when used together. Our results could inform the use of weightlifting belt and wrist straps in recreational weightlifters.

2. Methods

2.1. Experimental approach

This study used a repeated-measures, within-subjects design. Following a warm-up (described in Beckham et al),[16] all participants underwent weightlifting assessments with and without using a belt and/or wrist straps (condition 1: belt and straps; condition 2: belt alone; condition 3: straps alone; and condition 4: no belt and no straps) during a conventional deadlift with a loaded barbell. Measurements included hip and knee flexion angles in the starting position of a conventional deadlift and cervical lordosis, thoracic kyphosis and lumbar lordosis angles in the finishing position, in addition to the total time taken to complete a conventional deadlift and self-reported RPE. The order of testing conditions was randomized, and all tests were performed within 1 day.

2.2. Participants

From January to April 2021, a sample of weightlifters were recruited from 2 local gyms and the Education University of Hong Kong through social media advertising and personal invitations. The inclusion criteria were men aged 18 to 30 years who have more than 3 years of weightlifting experience, have been training at least 4 hours per week, and engage in recreational weightlifting. The exclusion criteria were men with musculoskeletal disorders (e.g., leg length discrepancies and severe flat feet), neurological disorders (e.g., epilepsy), spinal problems (e.g., scoliosis), upper limb problems (e.g., history of shoulder dislocation, tennis or golf elbow) or recent injuries that could affect performance or who train regularly for other sports. Participants were asked to refrain from any type of exhausting activity for 48 hours prior to data collection to avoid muscle fatigue. The study was approved by the Human Research Ethics Committee (Department of Health and Physical Education) of the Education University of Hong Kong on November 19, 2020. Informed written consent was obtained from each participant prior to data collection. All procedures were performed according to the Declaration of Helsinki.

Basic demographic information and information regarding weightlifting experience were collected by interview. Body weight and height were measured, and body mass index was calculated. Handgrip strength of both hands and the conventional deadlift one-repetition maximum (1RM) of each participant were measured using a handgrip dynamometer and a loaded barbell, respectively. For the deadlift 1RM test the use of supportive aids was not permitted, but the use of chalk was allowed. The 1RM test protocol included a warm-up, loading increments and rest periods according to a previously established protocol.[10] Procedures followed during the 1RM test were as described below. The participants were given a 30-minute recovery period following the 1RM test prior to experimental data collection.

2.3. Procedures

Data collection was performed in the Physical Fitness Room of the Education University of Hong Kong or a local gymnasium by 3 student researchers with personal trainer or weightlifting coaching qualifications. Blinding of assessors were not feasible given the nature of the interventions (wearing different weightlifting devices). The participants wore a weightlifting belt (Heavywear Nylon Contour Belt H9, NC) for the "with weightlifting belt" conditions and/or put on a pair of wrist straps (Versa Gripps Professional Series, Versa Gripps, ME) for the "with wrist strap" conditions. The steps involved in completing a conventional deadlift have been detailed in Holmes.[17] In brief, during the setup phase (assuming the starting position), the participants stood with feet flat placed between hip- and shoulder-width apart, with toes pointing slightly outward. With a slight flexion in both knees, the participants bent down toward the bar and let the hips move backward. They grasped the bar with a double overhand grip, placing their hands slightly wider than shoulder-width apart, with both elbows fully extended. The participants then lowered their hips further until their shins touched the bar. They were reminded to keep their back flat to maintain a neutral spine

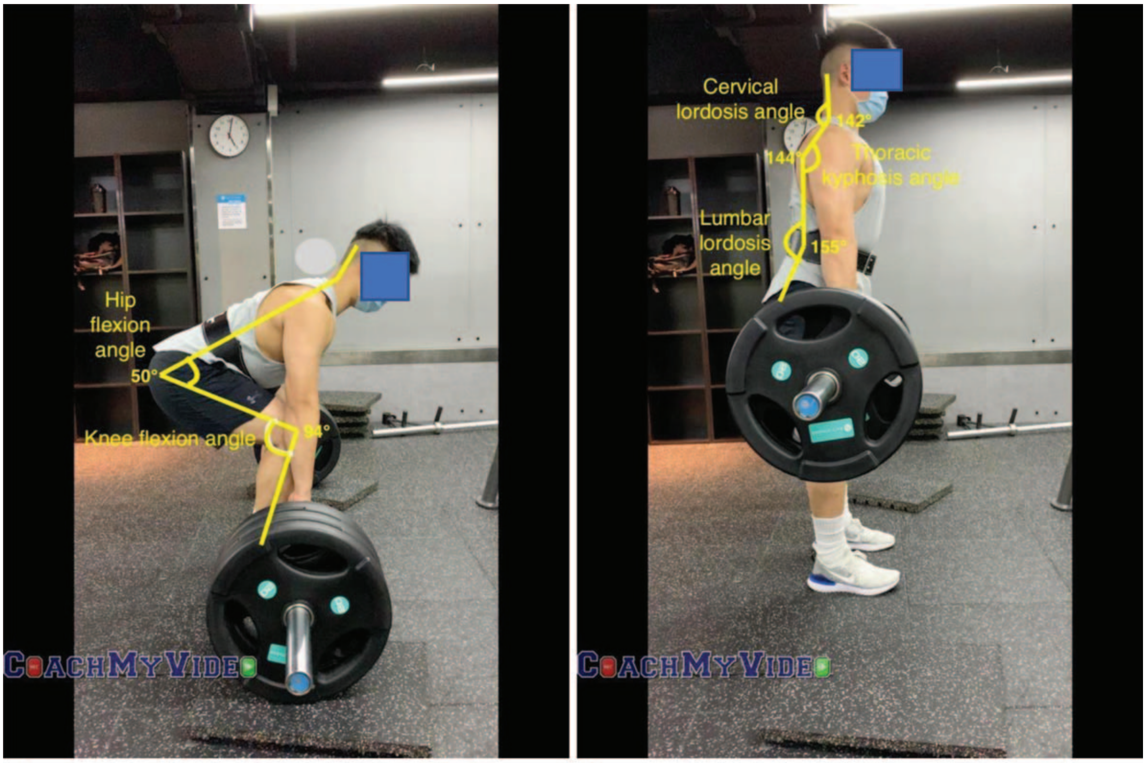

Figure 1. Angle definitions. (A) Hip and knee joint flexion angles in the setup phase and (B) cervical lordosis, thoracic kyphosis, and lumbar lordosis angles in the lockout phase of a deadlift.

(Fig. 1A). During the upward phase, the participants lifted the bar by extending the hips and knees until the body reached an upright standing position (lockout or finishing position) (Fig. 1B). During the lowering phase, the participants kept their back flat and bent their hips and knees to lower the bar to the floor. A spotter stood in front of each participant to ensure safety and instruct the participants to perform the lift at a comfortable speed without the use of Valsalva maneuver. The participants performed 1 deadlift repetition at 80% of their 1RM for each testing condition. The rest interval between testing conditions was 3 minutes.[18]

A video camera was used to record the deadlift movement in the sagittal plane. The Coach My Video software (CoachMyVideo, USA) (www.coachmyvideo.mobi) was used to extract kinematic data (primary outcomes) from these video clips. The test-retest reliability of this software was found to be good (intraclass correlation coefficient ranged from 0.7-0.8) in our pilot trial and the validity of this kind of motion analysis application has been reported to be excellent.[19] The kinematic data extraction method was based on Gong et al[20] and is described below. During the setup phase, hip flexion describes the angle between the trunk and thigh, whereas knee flexion is the angle between the thigh and shank. Smaller values represent a greater range of motion or a deeper squat (Fig. 1A). Cervical lordosis describes the angle formed between the head and neck. Similarly, thoracic kyphosis describes the angle between the neck and trunk. Lumbar lordosis describes the angle between trunk and hip. In these cases, smaller values represent increased lordosis/kyphosis (Fig. 1B). All kinematic data extraction was based on fixed bony landmarks and with reference to goniometric measurement of joint angles.[21] Additionally, the total time required to complete a deadlift (i.e., timed from the moment the bar was lifted off the floor to the moment the bar was placed on the floor again, a secondary outcome measure) was recorded. A shorter completion time indicates greater explosive power.[22] After each testing condition, the participants were asked to quantify their overall perceived exertion on a modified RPE scale (another secondary outcome measure). The scale ranged from 0 (resting) to 10 (maximal), with lower scores indicating less perceived exertion.[23]

2.4. Statistical analyses

Power analysis was performed using the GPower 3.1 software (Franz Faul, University of Kiel, Germany). Assuming a medium effect size of 0.28, a 2-tailed alpha level of 0.05 and a statistical power of 0.8, a minimum of 19 participants were required.

Data were analyzed using SPSS 26.0 software (IBM, Armonk, NY). The overall significance level (alpha) was set at 0.05 (2-tailed). Two-way repeated measures analysis of variance was used to compare primary outcomes (hip and knee flexion angles; cervical lordosis, thoracic kyphosis and lumbar lordosis angles); and secondary outcomes (time to complete a deadlift and RPE) across different conditions. Within-subject factors were the use of a belt and/or straps. A post-hoc paired t test with Bonferroni correction (i.e., alpha = 0.0083) was performed to identify whether any significant results were obtained for the outcome variables. The effect size (partial eta-squared [n_p^2]) was also

Table 1

Characteristics of the male recreational weightlifters (n=20).

Variable	Value
Age (year)	23.1±2.5
Height (cm)	175.8±5.0
Weight (kg)	72.9±8.3
Body mass index (kg·m^{-2})	23.6±2.4
Weightlifting experience (year)	4.6±1.6
Weightlifting training time (hours per week)	10.3±2.6
Average handgrip strength (kg)	46.9±5.3
Deadlift 1 RM (kg)	76.0±0.0

Values are presented as mean±standard deviation.
1 RM=one-repetition maximum.

reported. Values of 0.14, 0.06 and 0.01 denote large, medium, and small effect sizes, respectively.[24]

3. Results

Twenty male recreational weightlifters participated in the study. No injuries or adverse events were reported during data collection. The characteristics of the participants are detailed in Table 1.

Regarding knee flexion during the deadlift setup phase, our data revealed an overall significant main effect of using wrist straps ($F_{1,19}=6.275$, $P=.022$, $n_p^2=0.248$) or a belt ($F_{1,19}=5.498$, $P=.030$, $n_p^2=0.224$). However, the belt-straps interaction effect was not significant ($F_{1,19}=1.068$, $P=.314$, $n_p^2=0.053$). Post-hoc analyses indicated that wearing both a belt and straps (condition 1) reduced knee flexion by an average of 4.85° compared to the control (condition 4, no aids) ($P<.001$). However, for hip flexion during the setup phase, no significant effects were seen in any testing condition (all $P>.05$) (Table 2).

An overall significant main effect was seen on thoracic kyphosis during the lockout phase in the straps condition ($F_{1,19}=10.967$, $P=.004$, $n_p^2=0.366$); however, both the effects of the belt condition ($F_{1,19}=1.520$, $P=.233$, $n_p^2=0.074$) and belt-straps interaction ($F_{1,19}=0.036$, $P=.851$, $n_p^2=0.002$) were not significant. Post-hoc analysis revealed that using straps alone (condition 3) decreased thoracic kyphosis by 3.1° compared to that when using a belt alone (condition 2) ($P<.001$). In terms of cervical and lumbar lordosis during the lockout phase, no significant effects were noted in any testing condition (all $P>.05$) (Table 2).

A significant main effect on the time taken to complete a deadlift was seen in the belt condition ($F_{1,19}=10.108$, $P=.005$, $n_p^2=0.347$). However, the main effect of the straps was not significant ($F_{1,19}=2.847$, $P=.108$, $n_p^2=0.130$), while the interaction effect of the belt-straps combination was also nonsignificant ($F_{1,19}=0.006$, $P=.937$, $n_p^2<0.001$). Post-hoc analysis revealed that using both a belt and straps (condition 1) reduced the time taken to complete a deadlift by 0.16 seconds compared to the control (condition 4) ($P=.008$). Additionally, using a belt (condition 2) reduced the deadlift completion time by 0.1 seconds compared to the control (condition 4) ($P=.007$) (Table 2).

Both the main effects of the straps condition ($F_{1,19}=37.089$, $P<.001$, $n_p^2=0.661$) and the belt condition on the RPE ($F_{1,19}=57.674$, $P<.001$, $n_p^2=0.752$) were significant. However, the belt-straps interaction effect on the RPE was not significant

Table 2

Outcome measures in the 4 testing conditions (n=20).

Testing condition	Hip flexion angle (setup phase, degree)	Knee flexion angle (setup phase, degree)	Cervical lordosis angle (lockout phase, degree)	Thoracic kyphosis angle (lockout phase, degree)	Lumbar lordosis angle (lockout phase, degree)	Time to complete a deadlift (s)	RPE
1. Belt and straps	56.50±4.67 (*95% CI*: 54.31-58.69)	88.55±11.65† (*95% CI*: 83.10-94.00)	142.60±12.86 (*95% CI*: 136.58-148.62)	143.20±8.70 (*95% CI*: 139.13-147.27)	155.60±8.80 (*95% CI*: 151.48-159.72)	1.40±0.23† (*95% CI*: 1.29-1.51)	4.05±1.67*,†,‡ (*95% CI*: 3.27-4.83)
2. Belt only	56.65±4.31 (*95% CI*: 54.63-58.67)	89.90±11.62 (*95% CI*: 84.46-95.34)	143.25±12.85 (*95% CI*: 137.24-149.26)	145.45±7.16* (*95% CI*: 142.10-148.80)	154.55±9.26 (*95% CI*: 150.22-158.88)	1.46±0.18† (*95% CI*: 1.37-1.54)	5.20±1.28† (*95% CI*: 4.60-5.80)
3. Straps only	55.15±3.56 (*95% CI*: 53.49-56.82)	90.50±10.44 (*95% CI*: 85.62-95.38)	143.85±14.27 (*95% CI*: 137.17-150.53)	142.35±8.07 (*95% CI*: 138.57-146.13)	154.15±8.42 (*95% CI*: 150.21-158.09)	1.50±0.21 (*95% CI*: 1.40-1.59)	5.90±1.29† (*95% CI*: 5.30-6.51)
4. No belt and no straps	55.70±4.24 (*95% CI*: 53.71-57.69)	93.40±12.55 (*95% CI*: 87.53-99.27)	142.20±11.07 (*95% CI*: 137.02-147.38)	144.30±7.39 (*95% CI*: 140.84-147.76)	155.30±9.55 (*95% CI*: 150.83-159.77)	1.56±0.23 (*95% CI*: 1.45-1.66)	7.05±1.40 (*95% CI*: 6.40-7.70)

Values are presented as mean±standard deviation.
CI=confidence interval, RPE=rating of perceived exertion.
* $P<.0083$ compared with strap only condition (condition 3).
† $P<.0083$ compared with no belt and no straps condition (condition 4).
‡ $P<.0083$ compared with belt only condition (condition 2).

($F_{1,19} < 0.001$, $P = 1.000$, $\eta_p^2 < 0.001$). Further analysis revealed that using both a belt and straps (condition 1) resulted in the lowest RPE score compared to using a belt alone (condition 2) (mean difference = 1.15, $P < .001$), using straps alone (condition 3) (mean difference = 1.85, $P < .001$) and using no aid at all (condition 4) (mean difference = 3.00, $P < .001$). When comparing the use of individual aids to the control condition (condition 4), using both a belt alone (condition 2) (mean difference = 1.85, $P < .001$) and straps alone (condition 3) (mean difference = 1.15, $P < .001$) resulted in lower RPE scores (Table 2).

4. Discussion

Our results reveal that using a combination of a weightlifting belt and wrist straps reduced knee flexion, but not hip flexion, during the deadlift setup phase compared to using no aid. The participants therefore squatted deeper by bending exclusively their knees more when wearing the belt and straps. This finding partially agrees with that of Giorcelli et al,[25] who reported that using a lifting belt increased both hip and knee flexion (i.e., more likely to use a squat-lift) when preparing to lift a heavy box. No increase in hip flexion range was noted in our participants when wearing a belt, likely because the starting position of a deadlift differs significantly from that assumed when lifting a box. Our weightlifters were requested to touch their shins to the bar, as this may shift the center of gravity anteriorly. To prevent the upper body from leaning forward too much, maintaining hip flexion (i.e., trunk inclined posteriorly) may assist in postural stability when executing the deadlift.[17] The increased knee flexion range observed during the setup phase when the participants were wearing both a belt and straps may be a compensatory strategy for the reduced lumbar[26] and wrist joint[15] range of motions resulting from the use of these aids. However, further biomechanical analyses are needed to confirm this hypothesis.

The influence of using a weightlifting belt and wrist straps on spinal angle was most significant in the thoracic region during the lockout phase. Using straps alone decreased the thoracic kyphosis angle (i.e., increased thoracic kyphosis) when compared to using a belt alone. This finding was not surprising considering 2 reasons. First, the weighted barbell falls anterior to the lifter's center of gravity, and both hands were securely attached to the bar by straps (Fig. 1B). Muscles in the posterior chain, including erector spinae, middle trapezius and the rhomboids, must contract eccentrically to prevent the excessive thoracic kyphosis[17] induced by the frontloaded weighted barbell. As we used a weight of 80% of the 1RM in the deadlift tests, which is a very heavy load, the posterior chain muscles in the thoracic region may not have been strong enough to counteract such excessive thoracic kyphosis. Second, spinal curvatures may have been altered by the use of a weightlifting belt. Weightlifting belts are known to be effective in reducing spinal shrinkage[6] and excessive lumbar lordosis[7] associated with spinal loading. They may, therefore, also prevent an exaggerated kyphotic-lordotic posture (i.e., reduce both lumbar lordosis and thoracic kyphosis)[27] during lockout, even when the barbell is relatively heavy. Further kinematic and kinetic analyses of deadlifts carried out with belts and/or straps is warranted to confirm these hypotheses. Further studies are also required to explore why lumbar lordosis and cervical lordosis did not significantly differ across the 4 testing conditions. It might be related to the participants' training experience, habit and torso stability that may not be easily affected by the use of external aids.[28]

In contrast to a previous study that reported that wearing a weightlifting belt was associated with slower deadlift velocities,[15] we found that performing deadlift with a belt alone reduced deadlift completion time significantly. Such a discrepancy in findings could be due to the different units of measurement used in different studies. In their study, Coswig et al[15] measured both displacement and time (velocity) of a deadlift repetition, whereas in our study, we measured the completion time of a single deadlift. In fact, consistent with our study, other studies have reported that the use of a weightlifting belt can reduce the time taken to perform a squat. It might be attributed to the improved confidence during squatting with a belt.[29,30] However, the exact mechanisms responsible for this reduced time remain unclear and require further research. When using straps in combination with a belt, we found that deadlift completion time was further reduced (Table 2). These findings align with those of Jukic et al,[13] who reported that using straps resulted in greater mean and peak movement velocities during deadlifts due to improved grip strength and security.[13] Certainly, further studies are required to investigate the combined effects of lifting belt and straps on the load-velocity profile of weightlifters during the deadlift exercise.[31]

Our participants perceived the least exertion when wearing both a belt and straps, less exertion when wearing a belt alone or straps alone, and considerably more exertion when using no aid (Table 2). These findings align with the deadlift completion times and results of previous studies,[10,32] which reported that using more supportive devices (i.e., both a belt and straps) resulted in shorter deadlift completion time and the participants reported less perceived intensity of effort. Indeed, an inverse relationship has been established between movement velocity and RPE during deadlifts.[32] This suggests that any potential placebo effect associated with the use of these supportive devices is non-negligible and might affect weightlifting performance.

Nevertheless, several limitations exist in this study. First, we only analyzed lower limb joints and spinal angles in the sagittal plane during the setup and lockout phases of deadlift. Further studies should include 3-dimensional kinematic analyses throughout the setup, upward, lockout and lowering phases to provide a more complete picture. Second, the participants' footwear was not standardized, despite being known to affect conventional deadlift time and velocity.[33] Third, sports performance (i.e., maximum weight lifted), deadlift kinetics and history of back injury were not determined in this study. Finally, as the study was performed in male recreational weightlifters, our results cannot be generalized to female weightlifters or to weightlifters at other levels.

Despite these limitations, our results suggest that wearing both a belt and wrist straps can promote a deeper squat during the setup phase and as a result might reduce the risk of lower back injuries. Using both a belt and straps also reduces the time taken to complete a deadlift and reduces overall RPE in male recreational weightlifters. However, using straps alone may exaggerate thoracic kyphosis during lockout. Coaches and trainers should thus recommend recreational weightlifters to use both a belt and straps together, but not straps alone, when performing deadlift training.

5. Conclusion

Wearing both a weightlifting belt and wrist straps reduced knee flexion, but not hip flexion, during the setup phase of deadlifts in male recreational weightlifters. Using wrist straps alone exaggerated thoracic kyphosis in the lockout phase. No significant changes were seen in terms of cervical and lumber lordosis with the use of a belt and/or straps. Additionally, less time was taken to complete a deadlift and less exertion was perceived when wearing a belt and/or straps. Thus, using a weightlifting belt and wrist straps is recommended for recreational weightlifters to improve lifting kinematics, shorten the time taken to perform a deadlift and decrease perceived exertion. However, using wrist straps alone is not recommended as it may exaggerate thoracic kyphosis and could lead to injury.

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