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STRENGTH TRAINING

# Comparison of Training Effects of Split-Style Olympic Lifts and Squat-Style Olympic Lifts on Performance in Collegiate Volleyball Players

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## Abstract

*This study compared the training effects of split-style Olympic lifts (SP-L) with those of squat-style olympic lifts (SQ-L). In the study, the participants (n = 33 collegiate female volleyball players) were sorted on a random basis into the SP-L group (age = 15.80 ± 1.03 years; height = 164.50 ± 3.96 cm; body weight = 60.88 ± 8.26 kg), SQ-L group (age = 15.22 ± 1.2 years; height = 167.78 ± 3.53 cm, body weight = 62.02 ± 7.20 kg), and control group (CG; age = 15.14 ± 0.38 years; height = 165.29 ± 5.25 cm; body weight = 61.32 ± 5.89 kg). The groups performed split and squat snatch and clean and jerk twice a week for 6 weeks. Analysis of variance and magnitude-based inferences determined whether there was a significant difference in the measured variables among groups. In the groups, compared with the pretraining values, a significant and positive improvement was noted in posttraining leg stiffness and time to 5-m and 20-m sprint. However, for the time to 5-m sprint, the gains in the SP-L group were better (large/d = 1.79). In addition, an increase to spike jump and change of direction in the SP-L group alone was significant for the main effect of time (p < 0.05). The results of this study indicate*

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I would like to thank the athletes for their participation in the study.

*that SP-L are more effective for spike jump, change of direction, and time to 5-m sprint. Although the results of the study provide insights regarding the beneficial effects of training with SP-L rather than SQ-L, consolidation of the study results with the results of future studies is warranted.*

Effective development of maximum strength and power is necessary in many individual and team sports. Therefore, athletes routinely perform strength training to improve performance-based neuromuscular abilities, such as power and strength. Olympic weightlifting (OW) is a dynamic strength–power sport in which the athletes aim to lift the highest weight by applying the techniques of snatch and clean and jerk (Chiu & Schilling, 2005). The snatch and clean and jerk are complex whole-body movements involving a high intensity of muscular contractions. For many years, athletes have used OW to develop abilities such as strength, power, and speed for recreational and professional purposes (Lloyd et al., 2012). Athletes have long used Olympic lifts and their variations as strengthening techniques to enhance sports performance. These Olympic lifts and their variations have also been included in the strength and fitness programs of several sports and have been subjected to numerous scientific research studies (Ayers et al., 2016; Comfort et al., 2011, 2013; Helland et al., 2017; Hoffman et al., 2004; Holmberg, 2013; Hori et al., 2005; Janz & Malone, 2008; Suchomel et al., 2017).

Sports experts seem to be convinced that OW exercises are highly efficient for developing functional power (Tricoli et al., 2005). It has been shown that squat-style snatch and clean and jerk techniques as well as their derivatives produce more effective training stimuli for the lower extremity (Suchomel et al., 2017) and are generally considered to be a superior training method for explosiveness (Haff et al., 2001; McBride et al., 1999; Stone, 1993). The results of previous studies reveal that squat-style full weightlifting movements are more beneficial than other training methods. Six weeks of high pulls, squat-style power cleans training leads to a better strength output increase than kettlebell training (Otto et al., 2012). Similarly, in another study, 6-week squat-style snatch and clean training revealed better vertical jump performance than traditional resistance training (Hoffman et al., 2004). A similar result was reported in the study by Arabatzi and Kellis (2012). In Tricoli et al. (2005), squat-style snatch and clean and jerk was more effective than plyometrics. Another study also showed that squat-style snatch and clean exercises are similarly more effective than traditional or plyometric exercises (Chaouachi et al., 2014). However, in contrast to the research mentioned, Helland et al. (2017) compared among squat-style snatch and clean exercises, motorized strength and power training, and free-weight strength and power training over 8 weeks in young athletes; they reported that squat-style snatch and clean training brought about smaller improvements in vertical jump. Although there are some contradictory results, it can be said that OW is generally more effective against other weight training programs.

Split-style lifts (SP-L) were performed in competitions in the 1960s (Chiu & Schilling, 2005). Currently, squat-style lifts (SQ-L) are used for performing snatch and clean movements in OW competitons and in other events. Therefore, SQ-L is primarily considered as the Olympic lift technique among sports professionals. In fact, as far as I know, all the aforementioned scientific studies included SQ-L exercises. Anecdotally, SP-L exercises are considered easier to learn, and for some people, especially those who have flexibility, agility, and balance issues, SP-L might be a better option. Generally, there are substantial differences between weightlifters with good OW techniques and athletes participating in other sports that often engage in OW as part of their training. Athletes who lift the Olympic lifts with unsuitable techniques can reduce or remove the transfer of these lifts to other possible abilities, such as jumping and running (Helland et al., 2017). Thus, it can be said that SP-L seems to be more effective for different populations, such as beginners in sports as well as young or female athletes with weaker squat technique and body structure. There are also some concerns that some OW programs do not always translate to better performance in sports, owing to the complex techniques (Chiu & Schilling, 2005). SP-L technique is easier to learn than SQ-L and thus the aforementioned concerns can be eliminated. In addition, for successfully performing SP-L, a person needs to raise the barbell higher than that done in SQ-Ls, which means that generation of greater speed and force is warranted. Thus, I hypothesized that SP-L-based training would be more effective than SQ-L-based training with regard to enhancement of athletic performance. Therefore, the aim of this study was to address the gaps in the literature concerning SP-L exercises because, to my knowledge, the effects of SP-L in athletes have not been investigated in any studies to date, except in only one of my previous studies (İnce, 2019). However, in my study, I could not compare between the effects of SP-L and SQ-L training exercises. For this reason, I also aimed to compare between the effectiveness of SP-L and SQ-L training techniques.

# Method

## Experimental Methods to the Problem

I performed pre- and posttests to compare SP-L and SQ-L exercises based on six performance variables, namely, spike jump (SJ), counter movement jump (CMJ), change of direction (COD), and leg stiffness (LS) as well as time to 5-m (S5) and 20-m (S20) sprint, of female collegiate volleyball players. The participants were randomly divided into three groups: the training groups (in addition to normal volleyball training, SP-L or SQ-L exercises were performed 2 days/week) and control groups (normal volleyball training only). Ramdomization was done based on a draw; each participant drew from a selection of two preprepared folded sheets of paper, which were identical in size, with the designated group names written on them. The training program lasted for 6 weeks, and all participants received the same pre- and posttraining test protocol.

## Subjects

The participants were 33 female college volleyball players who had similar demographics and activity backgrounds. Table 1 shows the descriptive statistics of the participants. All participants were training at my university sports club and had 4.7 ± 1.38 years of volleyball experience as well as traditional weight training experience spanning over 3 to 4 months of the annual training period. Subjects were asked to maintain a normal diet during the study period. The participants and their families were informed regarding the possible risks and disturbances related to the experimental procedures, and their consent was obtained. The study protocol was approved by my university's ethics committee.

**Table 1**
*Descriptive Characteristics of Subjects*

| Characteristic | Total participants ($n$ = 33) ($M \pm SD$) | SP-LG ($n$ = 11) ($M \pm SD$) | SQ-LG ($n$ = 11) ($M \pm SD$) | CG ($n$ = 11) ($M \pm SD$) |
|---|---|---|---|---|
| Age (year) | 15.38 ± 0.98 | 15.80 ± 1.03 | 15.22 ± 1.20 | 15.14 ± 0.38 |
| Height (cm) | 165.88 ± 5.49 | 164.50 ± 3.96 | 167.78 ± 3.53 | 165.29 ± 5.25 |
| Body mass (kg) | 61.40 ± 7.11 | 60.88 ± 8.26 | 62.02 ± 7.20 | 61.32 ± 5.89 |
| BMI (kg/m$^2$) | 22.26 ± 2.26 | 22.48 ± 3.35 | 23.52 ± 2.41 | 20.79 ± 1.63 |
| Training year | 4.07 ± 1.38 | 4.08 ± 1.49 | 4.11 ± 1.62 | 4.02 ± 1.13 |

*Note.* SP-LG = split-style group; SQ-LG = squat-style group; CG = control group.

## Procedures

### Testing and Experimental Procedures

Tests were performed over 2 days in a resting state (no training 48 hr before the tests). On the first day, LS, CMJ, and SJ tests were performed, whereas on the second day, S5, S20, and COD tests were performed. A test familiarization session was not performed because the participants had taken these performance tests several times (at least 3) on a routine basis at certain intervals during their volleyball training session at the sports club of my university. Before the tests, subjects warmed up by performing a standard warm-up protocol comprising stretching exercises, jogging, and free jumps. Participants were motivated and encouraged to perform to their maximum capacity during all test sessions. All measurements were taken by the same researcher in the same environment.

### Anthropometric Measurements and Body Composition

The height of each athlete was measured using a stadiometer with 0.01-cm accuracy by following standard procedures (Holtain Ltd., Crymych, Dyfed, UK). The body composition was analyzed using a Bioelectrical Impedance Analyzer (BC-310, Tanita Corp., Tokyo, Japan).

## Leg Stiffness

LS tests were performed according to the protocol applied in a validity and reliability study (Ruggiero et al., 2016). Optojump Next (Microgate, Bolzano, Italy) stiffness protocol was applied. Two trials with a 2- to 3-min rest interval were conducted. The mean contact and flight times from all jumps obtained from the resulting vertical force–time trace as well as the body mass of participants were used in the calculation of LS. LS was calculated from the "Eq. 1" proposed by Dalleau et al. (2004).

## Spike Jump and Counter Movement Jump

Subjects were tested for SJ using previously established methods by Sattler et al. (2012). In SJ, the subject used an individualized 2- to 3-step approach and performed splashing with an arm rotation. This movement involved a vertical upward jump as fast as possible with a strong backward arm rotation. The subjects were asked to perform the jump procedure in a volleyball game or practice session, similar to their personal techniques, as they found the most appropriate. The specific procedures were relatively nonstandard because I wanted subjects to use their personal styles to perform the SJ test. For the CMJ test, the participants were requested to squat and jump vertically as quickly as possible with their hands on their waists, knees at full extension, and bodies upright. Pulling off the knees in the flight phase, pausing during movements, staying out of the Optojump Next and the parallel bar range, and stepping on the parallel bars were considered to be a failed test; this test was repeatedly performed. Two trials were performed for CMJ and SJ tests with a 2- to 3-min rest interval, and the best result was used for further analysis. CMJ and SJ tests were performed using the Optojump Next stiffness protocol.

## 5- and 20-m Sprint Tests

The participants started the test from the starting line, 1 m behind the starting photocell, when they felt ready. The measurements were obtained using photocell (Microgate, Bolzano, Italy) placed at the starting and finishing lines of the 5-m and 20-m race track. Two measurements were taken at 3- to 5-min rest intervals.

## Change of Direction

Standard *t* test determined COD ability. Four cones were placed in a T-shape arrangement. From the starting line of the first cone, the second cone was placed at a forward distance of 9.14 m, and two cones were placed at a distance of 4.57 m on the right and left sides, respectively, of the latter cone. The subjects should sprint in the forward direction up to a distance of 9.14 m from the starting line of the first cone and touch it with the tip of their right hand, run a side step with the left hand, move to the second cone that is 4.57 m to the left, touch the right cone at a distance of 9.14 m, and finally, touch the middle cone at a distance of 4.57 m. The test was considered to be complete when the subjects returned to the starting line. The timing was determined using a photocell placed on the starting line. Each participant performed two trials, which ensured reliability of the results. These trials were considered unsuccessful when participants did not contact a designated cone and did not smoothly run sideways or in the backward direction. The test was repeated twice (3- to 5-min rest intervals), and the best test result was considered.

## Training Programs

During the study, three groups participated in a standard volleyball training session conducted for 6 hr/week (3 sessions/week; 120 min/session) for 6 weeks. A standard volleyball training session includes both technical skill training and tactical skill training. Typical volleyball sessions were divided into warm-up, primary, and recovery periods. The warm-up took 20 min and included increased jogging time, a mazimum of six upper body exercises (push-ups, etc.), and both upper body stretching exercises and lower body stretching exercises. In the main part of the training session, on-site skill training (attack and defense basics, technical and tactical training, special cases) and actual volleyball playing took place. The work–rest ratio was 1:1.

Because my aim was to compare the effects of SP-L and SQ-L, I controlled all variables that could affect this comparison (i.e., no participant engaged in any upper body or lower body exercises). A 2-week adaptation program was organized to teach lifting techniques to the SP-L and SQ-L groups. A lightweight training bar made of wood was used in the adaptation program. After the adaptation program, 1RM (maximum weight that an individual can lift once) was determined by a direct 1RM perform (classical incremental method).

A standard warm-up protocol was established. The warm-up session took 20 min and included running, stretching exercises, and weightlifting with a very light training bar. The participants performed a progressive training protocol (2 days/week) for 6 weeks with an intensity rate ranging from 70% to 90%, which increased at a rate of 5% of 1RM/week. The training program was performed as 3 sets of 5 repetitions in the first week and increased by 1 set over 5 weeks. In the sixth week, the number of sets was reduced to 4 sets of 5 repetitions (Table 2). There was a 2-min rest between the sets. Each training session contained three movements of Olympic split lifts, hang split snatch, and clean and jerk. There was a 10-min resting interval between each movement. All athletes were supervised by the same coach, who was a former European gold medallist and a certified member of the National Weightlifting Federation. The athletes were encouraged to perform all their movements as fast and explosively as possible.

## Statistical Analysis

Descriptive statistics for all variables were expressed as mean and standard deviation. All data were converted to their log form, which ensured that the data were normally distributed. Two-way repeated-measures analysis of variance and Bonferroni post hoc tests determined the statistical difference between all variables. Additionally, the magnitude-based inference (MBI) method was used for statistical analysis (Hopkins et al., 2009). The probability of a standardized magnitude (0.35) effect on the variables in the pre- and posttest was calculated with Cohen's *d*, and the effect size classification for strength training, as proposed by Rhea (2004) was used in this study. Based on this classification, less than 0.35 points indicates a trivial effect; 0.35 to 0.80, small effect; 0.80 to 1.50, moderate effect; and greater than 1.50, large effect. The differences in the variables were characterized by probabilistic terms, and the following scale was used: < 0.5%, most unlikely; 0.5–5%, very unlikely; 5–25%, unlikely; 25–75%, possibly; 75–95%, likely; 95–99.5%, very likely; > 99.5%, most likely. The inference was categorized as unclear because 95% confidence limits overlapped with the threshold values

**Table 2**

*Volume (Set/Repeat) and Intensity Rates of Split Group and Squat Group Training Programs*

| | **Week 1** | | | **Week 2** | | | **Week 3** | | | **Week 4** | | | **Week 5** | | | **Week 6** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Group** | **S** | **R** | **%** | **S** | **R** | **%** | **S** | **R** | **%** | **S** | **R** | **%** | **S** | **R** | **%** | **S** | **R** | **%** |
| Split group | | | | | | | | | | | | | | | | | | |
| Split hang power snatch | 3 | 5 | 70 | 4 | 5 | 75 | 5 | 5 | 80 | 2 | 5 | 85 | 7 | 5 | 90 | 4 | 5 | 70 |
| Split hang power clean | 3 | 5 | 70 | 4 | 5 | 75 | 5 | 5 | 80 | 3 | 5 | 85 | 7 | 5 | 90 | 4 | 5 | 70 |
| Split jerk | 3 | 5 | 70 | 4 | 5 | 75 | 5 | 5 | 80 | 3 | 5 | 85 | 7 | 5 | 90 | 4 | 5 | 70 |
| Squat group | | | | | | | | | | | | | | | | | | |
| Squat hang power snatch | 3 | 5 | 70 | 4 | 5 | 75 | 5 | 5 | 80 | 2 | 5 | 85 | 7 | 5 | 90 | 4 | 5 | 70 |
| Squat hang power clean | 3 | 5 | 70 | 4 | 5 | 75 | 5 | 5 | 80 | 3 | 5 | 85 | 7 | 5 | 90 | 4 | 5 | 70 |
| Power jerk | 3 | 5 | 70 | 4 | 5 | 75 | 5 | 5 | 80 | 3 | 5 | 85 | 7 | 5 | 90 | 4 | 5 | 70 |

for the smallest worthwhile positive and negative effects (Hopkins et al., 2009).

# Results

## Test Reliability

Intraclass correlation coefficient results were reliable: LS, $r = 0.94$ (0.89 to 0.98); S5, $r = 0.95$ (0.92 to 0.99); COD, $r = 0.93$ (0.88 to 0.97); CMJ, $r = 0.92$ (0.87 to 0.97); and SJ, $r = 0.89$ (0.81 to 0.93).

## Analysis of Variance

The results for LS indicated a significant main effect and Time × Group interaction for split-style and squat-style group ($p < 0.05$). Post hoc analysis revealed an improvment in LS in both split- and squat-style groups, but this was not noted in the control group. Similarly, analysis of variance indicated a significant Time × Group interaction effect on 5-m sprint time ($p < 0.05$). Post hoc analysis revealed that both the split- and squat-style groups had an improved 5-m sprint time compared to that of the control group. There was a significant Time × Group interaction for 20-m sprint time ($p < 0.05$). The results indicated that gains for the split- and squat-style groups were greater than that for the control group ($p < 0.05$). For COD, analysis of variance results indicated a significant Time × Group interaction effect ($p < 0.05$). The split-style group showed a significant increase from that of the control group. CMJ test results indicated no significant difference in the main effect and Group × Training interaction between squat-style and control groups ($p > 0.05$). SJ test results revealed only a significant main effect in the split-style group ($p < 0.05$).

## Magnitude-Based Inferences

### *Split-Style Group*

SP-L training elicited a very likely probability of positive improvement in LS (98.4% "small" $d = 0.79$) as well as most likely probability of a positive effect on time to 5-m sprint (99.8% "large" $d = 1.79$); very likely, positive effect on time to 20-m sprint (95.9% "moderate" $d = 1.24$); possibly, positive effect on change of direction

(57.1%, "small" $d = 0.40$); and possibly, positive effect on SJ (72.6%, "small" $d = 0.53$). MBI was only unclear for CMJ ($d = -0.11$).

### Squat-Style Group

SQ-L training elicited a very likely probability of positive improvement in LS (98% "small" $d = 0.70$) as well as a very likely probability of a positive effect on time to 5-m sprint (98.9% "moderate" $d = 1.79$); very likely, positive effect on time to 20-m sprint (98.2% "moderate" $d = 0.87$); and possibly, positive effect on change of direction (55.6% "small" $d = 0.39$). MBI was trivial for SJ ($d = 0.12$) and unclear with regard to CMJ ($d = -0.15$).

### Control Group

MBI was unclear for LS ($d = 0.29$), time to 5-m sprint ($d = 0.42$), and time to 20-m sprint ($d = 0.06$), whereas it was trivial for SJ ($d = 0.32$), change of direction ($d = 0{,}01$), and CMJ ($d = 0.26$).

## Discussion

This study compared the training effects of SP-L and SQ-L on LS, S5, and S20 sprint as well as on COD, CMJ, and SJ. To the best of my knowledge, this is the first study to compare the effects of SP-L and SQ-L. This study confirms the results of İnce (2019). In both studies, the same training program was administered to the participants with similar characteristics for the same period, and the same variables were evaluated. In this study, which is different from the İnce study, I aimed to compare the effect of SP-L exercises by including the SQ-L group. The hypothesis of the study was that SP-L-based training would be more effective than SQ-L-based training. This hypothesis was confirmed for S5, COD, and SJ performances. Although the MBI for COD performance in the SQ-L group was similar to that in the SP-L group, this was not confirmed by analysis of variance. In addition, although the difference in Time × Group interaction was not significant for SJ, the main effect was significant only in the SP-L group. Therefore, it is important to be careful while generalizing the aforementioned results of the study variables.

An important result of this study was that there was no significant increase in CMJ performance. In several studies, OW has been shown to be highly effective for vertical jump. Canavan et al. (1996)

**Table 3**

*Pretesting and Posttesting Results, Analysis of Variance, and Magnitude-Based Inference Chances for Positive/Negative/Unclear/Trivial Training Effects*

| | **Split group (N = 10)** | | | | **Squat group (N = 10)** | | | | **Control group (N=10)** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Performance variable** | **Pre *M* ± *SD*** | **Post *M* ± *SD*** | **Cohen *d*** | **MBI** | **Pre *M* ± *SD*** | **Post *M* ± *SD*** | **Cohen *d*** | **MBI** | **Pre *M* ± *SD*** | **Post *M* ± *SD*** | **Cohen *d*** | **MBI** |
| LS (kNm$^1$) | 31.39 ± 6.7 | 36.01 ± 4.77$^{\#*c}$ | 0.79<br>small | 98.4/1.6/0.0<br>very likely positive | 30.73 ± 6.44 | 35.96 ± 7.29$^{\#*c}$ | 0.70<br>small | 98/0.1/2<br>very likely positive | 39.19 ± 16.33 | 36.82. ± 7.36$^{*a.b}$ | 0.29<br>trivial | 73.9/0.5/25.7<br>unclear |
| S5 (s) | 1.25 ± 0.07 | 1.12 ± 0.06$^{\#*c}$ | 1.79<br>large | 99.8/0.2/0.1<br>most likely positive | 1.29 ± 0.12 | 1.15 ± 0.09$^{\#*c}$ | 1.17<br>moderate | 98.9/1.000<br>very likely positive | 1.16 ± 0.07 | 1.13 ± 0.07$^{*a.b}$ | 0.42<br>small | 39.8/56.2/4.0<br>unclear |
| S20 (s) | 3.64 ± 0.11 | 3.51 ± 0.108$^{\#*c}$ | 1.24<br>moderate | 95.9/3.7/0.4<br>very likely positive | 3.83 ± 0.20 | 3.66 ± 0.19$^{\#*c}$ | 0.87<br>moderate | 98.2/1.8/00<br>very likely positive | 3.69 ± 0.16 | 3.70 ± 0.15$^{*a.b}$ | 0.06<br>trivial | 11.3/82.1/6.6<br>unclear |
| COD (s) | 11.63 ± 0.77 | 11.35 ± 0.64$^{\#c}$ | 0.40<br>small | 57.1/41.5/1.5<br>possibly positive | 12.14 ± 0.9 | 11.84 ± 0.54 | 0.39<br>small | 55.6/42.6/1.8<br>possibly positive | 12.70 ± 1.04 | 12.71 ± 0.92 | 0.010<br>trivial | 3.0/94.3/2.7<br>likely trivial |
| CMJ (cm) | 27.6 ± 2.49 | 26.7 ± 1.43 | -0.11<br>trivial | 10.1/47.8/42.1<br>unclear | 25.09 ± 4.12 | 24.79 ± 3.56 | -0.15<br>trivial | 1.4/92.1/6.5<br>likely trivial | 26.7 ± 3.8 | 27.01 ± 3.55 | 0.26<br>trivial | 3.7/65.4/30.9<br>possibly trivial |
| SJ (cm) | 37.1 ± 3.75 | 39.78 ± 2.45$^{\#}$ | 0.53<br>small | 72.6/25.8/1.6<br>possibly positive | 35.32 ± 6.04 | 36.03 ± 5.29 | 0.16<br>trivial | 22.5/70.8/6.7<br>unclear | 35.42 ± 3.98 | 36.24 ± 3.99 | 0.22<br>trivial | 49.7/44.5/5.8<br>unclear |

*Note.* MBI = magnitude-based inference.

[a] Different from split group. [b] Different from squat group. [c] Different from control group.

[#] Significant for time at $p < 0.05$. [*] Significant for Time × Group at $p < 0.05$.

found many associations between vertical jump programs and hang clean in kinetic and kinematic parameters, which means that these two abilities were very similar to mechanics. A strong association of squat-style hang snatch and clean with vertical jump was noted (Carlock et al., 2004; Hori et al., 2008). Tricoli et al. (2005) reported significant improvements in CMJ and squat jump among university students trained using OW for 3 sessions/week for 8 weeks. Channell and Barfield (2008) showed that 8-week OW training significantly improved vertical jump performance among high school athletes. Similarly, Chaouachi et al. (2014) showed that 8-week OW training provided better training adaptation in CMJ and horizontal jump performance. Unlike these studies, Hoffman et al. (2004) found no statistically significant improvement in vertical jump performance after 15 weeks of OW training in collegiate football players, but it was noted that OW was better than traditional strength training and that vertical jump tended to improve. Thus, the results of this study are not similar to the results of most studies. In another study by Helland et al. (2017), OW training resulted in smaller improvements in jumping performances than did other training modalities. This may be because I only applied an OW training protocol. Thus, other upper and lower body exercises along with OW training may result in better adaptation.

Similarly, in the study conducted by Helland et al. (2017), OW exercises alone applied to a worse performance in vertical jump perfromance and this seems to support my opinion. In this study, although there was no group interaction for CMJ performance, SP-L training for SJ performance resulted in a better adaptation. SP-L exercises and SJ can have a more similar pattern, which facilitates a better adaptation. Future research involving biomechanical parameters might give clearer results.

In addition, Helland et al. (2017) demonstrated that upper body muscles were highly active during OW training, which consequently alleviated the burden on lower body muscles. Thus, upper body adaptations may also affect jump performance. Considering the CMJ–akimbo test result and the increase in SJ performance in the SP-L group, it seems reasonable to suggest that OW training increases vertical jump performance, owing to the training responses in the upper body. Feltner et al. (1999) suggested that the reaction force acting on the trunk owing to an upward acceleration of the arms causes subjects to produce greater muscle strength by slowing down the extension rates of their hip, knee, and ankle joints. In addition, in a weightlifting performance prediction study, the free CMJ, but not akimbo CMJ, entered the regression model (İnce & Ulupinar, 2020). Another reason contributing to 6-week OW causing insufficient adaptation could be the nature of volleyball training, which has a large scope for jumping activity.

In this study, the best training adaptation was noted in the performance of the SP-L group S5. Although there is no clearer difference in COD performance between the SP-L and SQ-L groups, SP-L are highly effective for sprint performance. Thus, SP-L seem to have a more functional movement pattern on sprint performance. Tricoli et al. (2005) reported significant improvements in 10-m sprint, CMJ, and squat jump among university students trained with OW for 3 sessions/week over 8 weeks. Chaouachi et al. (2014) showed that an 8-week OW training provided better training adaptation for S5 and S20 performances. Hoffman et al. (2004) did not find any significant difference in sprint and COD results in their research. Another study by Helland et al. (2017) demonstrated smaller improvements in jumping and sprinting performances of young athletes as a result of OW training. As mentioned, the training modality adopted in this study is similar to that adopted by Helland et al. and Chaouachi et al. (i.e., use of OW exercises alone rather than use of mixed training). Although the results of this study coincide with the results of Helland et al., they do not coincide with the results of Chaouachi et al., who found that children produced shorter responses to the training given to them.

SQ-L exercises had a significant effect on LS and the effect size was similar. According to expert opinions, although OW and its variations are emphasized as the basis for a stiffness program (Brazier et al., 2014), no specific research has been conducted regarding the training effects of OW and its variations on LS. Because stiffnes is known to have a great impact on running speed and vertical jump performance, most researchers believe that stiffness must be increased to improve sports performance (Brughelli & Cronin, 2008). Usually, the human body or body parts are modeled as a bow. Therefore, the stiffness in the human body or body parts describes the ability to resist displacement upon application of a ground reaction force or momentum (Serpell et al., 2012). In a study that involved the measurement of leg and joint stiffness, well-trained athletes were shown to have greater LS than their peers among the general population (Hobara et al., 2010). In a similar study, Hobara et al. (2008) found that power athletes had more LS than endurance training athletes. This shows that stiffness regulating force transmission is important, especially when efficient power transmission is important for performing a similar task (Hobara et al., 2008).

## Limitations

This study has some potential limitations. First, it may be inappropriate to generalize the results, owing to the relatively small number of participants in this study. However, I attempted to break this limitation by combining statistical hypothesis testing and MBI approaches, but MBI should also be considered in some of the debates concerning this topic. Second, although 2-week adaptation training session and 6-week training sessions were performed, this may not be sufficients for adaptations in some of the measured variables. Additionally, more explicit findings can be obtained by evaluating the effects of SP-L and SQ-L on kinetic and kinematic parameters so that the findings of this study can be validated. Third, only volleyball players were included in this study. The findings of this research can also be reinforced with different or integrated groups of athletes.

## Practical Applications

Today, there is widespread agreement regarding the effects of Olympic lifts on force and power, especially with regard to the explosive strength. Hence, Olympic lifts are increasingly being given importance in the strength and power training sessions of several sports. This study suggests that SP-L training is more efficient than SQ-L training. Thus, due to the simplicity of SP-L and the ease of application of SP-L for different populations, these results are important with regard to evaluation of sports performance and form the basis for the rationale behind the use of SP-L instead of SQ-L. This study also showed that SP-L produces a better improvement in SJ performance, which forms the basis for choosing SP-L exercises in volleyball strength training.

## Conclusion

The results of this study demonstrate that split-style lifts are more effective than squat-style lifts on 5-m sprint, change of direction, and SJ performance. This study was the first to compare the effects of SP-L with SQ-L. In addition, the effects of OW and its variations on athletic performance still remain controversial. Furthermore, extensive studies are needed in the field.

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