Loturco I et al. Jump Squat is More Related to Sprinting and Jumping Abilities than Olympic Push Press

Abstract

The aim of this study was to test the relationships between jump squat (JS) and Olympic push press (OPP) power outputs and performance in sprint, squat jump (SJ), countermovement jump (CMJ) and change of direction (COD) speed tests in elite soccer players. 27 athletes performed a maximum power load test to determine their bar mean propulsive power (MPP) and bar mean propulsive velocity (MPV) in the JS and OPP exercises. Magnitude-based inference was used to compare the exercises. The MPV was almost certainly higher in the OPP than in the JS. The MPP relative to body mass (MPP REL) was possibly higher in the OPP. Only the JS MPP REL presented very large correlations with linear speed ($r > 0.7$, for speed in 5, 10, 20 and 30 m) and vertical jumping abilities ($r > 0.8$, for SJ and CMJ), and moderate correlation with COD speed ($r = 0.45$). Although significant (except for COD), the associations between OPP outcomes and field-based measurements (speed, SJ and CMJ) were all moderate, ranging from 0.40 to 0.48. In a group composed of elite soccer players, the JS exercise is more associated with jumping and sprinting abilities than the OPP. Longitudinal studies are needed to confirm if these strong relationships imply superior training effects in favor of the JS exercise.

Introduction

Elite athletes competing in team sports are required to progressively develop their strength-power abilities to cope with increasing training and match demands related to involvement in high-intensity game-activities [2,47]. Muscle strength and power (assessed through laboratory measurements and field tests) are largely associated with the performance obtained in these specific dynamic sport tasks, such as jumping, sprinting and change of direction (COD) ability [8,49]. Consequently, strength and conditioning coaches frequently adopt complex multi-joint exercises as strategies to improve athletes’ muscle power, using exercises which simulate and mimic the sport specific movement patterns of the targeted motor tasks. In this regard, jump squats (JS) and Olympic weight lifts are amongst the preferred exercises implemented by coaches, due to their similarity to these “sport-specific mechanical requirements”. Nevertheless, the difficulties inherent in performing experimental investigations involving distinct training strategies among professional athletes have partly hampered the conduction of studies comparing the specific adaptations provided by different exercises (i.e., JS and/or Olympic push press [OPP]).

One alternative to explore the adequacy of implementing JS or Olympic lifting in soccer (which demands power-related abilities) is measuring the strength of associations between outcomes in these exercises and field-based power-speed performance. Although it is recognized that correlations do not necessarily imply cause and effect, it is intuitive that exercises with mechanical outcomes more strongly related to performance in jumping and speed abilities could be more effective when implemented in training routines than exercises weakly associated with sports performance, even though longitudinal evidence is necessary to confirm this possibility. In fact, several studies have shown that the load capable of maximizing the muscle power output assessed in JS is highly associated with sprint ability and is capable of discriminating between competitive levels in futsal and soccer players [12,29–31,39].

Key words

- muscle power
- olympic lifts
- strength training
- ballistic
- speed
Performing Olympic weight lifting exercises is one of the most common ways to improve neuromuscular function [16, 41]. Compared to JS, the widely used push press exercise tends to generate larger peak power and mean power while avoiding the impact of the landing phase [13, 24, 41]; therefore, it has been advocated that the OPP can be used as an effective means of improving power-related sports performance. To some extent, its popularity is owed to the relative simplicity of execution and similarity to sport-specific movements (such as jumping, accelerating, throwing, etc.). Furthermore, through a push press execution, the moment of force is exerted by the concomitant segmental extension provided by the torques applied around the knee and hip joints [10, 24]. Therefore, considering the similarities between JS and OPP and the significant correlations between the optimum load and specific sports performance [27–29], it is highly expected that the higher values of mean propulsive power (MPP) in the OPP will also be significantly associated with jump, speed and COD abilities in soccer players.

Recently, it has been suggested that training methods based on the optimum power zones may produce similar or even higher performance improvements than traditional strength training [32, 34, 35]. Additionally, for training under optimum power conditions, the athletes do not have to perform the 1-RM test, which may be more advantageous and safer for implementing and adjusting the strength-power training routines in professional team sports, whose players are faced with congested fixtures and busy training schedules [5, 9, 32]. More importantly, the possibility of reporting significant relationships between specific performance in field tests and the loads capable of maximizing the power outputs in JS and OPP may help strengthen and conditioning professionals to select the most effective training strategies to increase speed-power related abilities in their athletes. In addition, this knowledge might support the selection of exercises to be used in future research which could test the efficacy of these power-training strategies in experimental trials aimed at confirming this cause-effect relationship. Afterwards, these training strategies could be used to enhance the soccer players' field-based performance in specific motor tasks, such as jumps and maximal sprints. However, there is a lack of studies directly comparing the strength of associations between power outputs at the optimum loads obtained in the JS and OPP and field-based performance in highly trained soccer players. Therefore, the aim of this study was to test the relationships between JS and OPP maximum power outputs (measured directly from the barbell) and performance in vertical jump, sprint and COD speed tests in elite soccer players. Due to the high specificity of both these multi-joint complex exercises and the previous studies that have already reported strong correlations between the JS optimum power load and sport-specific performance [27–29], we hypothesized that both exercises would possess comparable large correlations with speed-power field-based measurements.

Methods

Experimental design
In this cross-sectional study, elite soccer players performed a maximum power load test in order to determine their bar maximum MPP and bar mean propulsive velocity (MPV) in the JS and OPP exercises. All athletes had been previously familiarized with the coordinative patterns of both exercises and all performed assessments due to their professional testing and training routines. In addition, their sprinting speeds at 5, 10, 20 and 30 m, and performance in the squat jump (SJ) and countermovement jump (CMJ) were assessed as representative of field-based specific soccer physical components. Comparisons between outputs presented by players in the JS and OPP were compared, and magnitudes of associations between these outputs and performance in sprint, COD and jump tests were assessed. Before all testing sessions, a general and specific warm-up routine was performed, involving light running (5-min at a self-selected pace followed by 3-min lower limb active stretching) and 3 submaximal attempts of each testing exercise (e.g., SJ and CMJ).

Subjects
27 high-level U-20 male soccer players from the same 1st division club (age: 18.40±1.20 years, height: 1.78±0.07 m, body mass: 74.40±9.50 kg, training experience: 7.20±1.90 years) took part in this investigation, after being informed of the potential benefits and risks associated with participation. The sample size was determined previously by G*Power software (v. 3.1.9.2) assuming α = 0.05, β = 0.20 and based on a previous study [32]. The study protocol took place prior to the São Paulo State U-20 Soccer Elite Championship, during the preseason-training period. The study procedures were approved by a local Ethics Committee, and the participants and their legal guardians (in the case of <18 years of age) signed an informed consent form prior to research commencement, being free to withdraw at any time without penalty. The current investigation also adhered to the standards of the International Journal of Sports Medicine described by Harris et al. [17].

Vertical jump tests
Vertical jumping height was determined using both SJ and CMJ. In the SJ, subjects were required to remain in a static position with a 90° knee flexion angle for 2-s before jumping, without any preparatory movement. In the CMJ, the soccer players were instructed to execute a downward movement followed by a complete extension of the legs and were free to determine the countermovement amplitude to avoid changes in jumping coordination. SJ and CMJ were executed with the hands fixed on the hips. All jumps were performed on a contact platform (Smart Jump; Fusion Sport, Coopers Plains, Australia) and the measured flight time (tJ, a time interval between take-off and landing) was used to estimate the height of the rise of the body’s center of gravity (h) during the jumps (i.e., $h = gt^2/8$, where $g = 9.81 \text{ m/s}^{-2}$). 5 attempts were allowed for each jump, interspersed by 15-s intervals and a given jump was only considered valid for analysis if the take-off and landing positions were visually similar. The best attempts at SJ and CMJ were retained for analyses.

Bar mean propulsive power and mean propulsive velocity in jump squat and Olympic push press
Bar MPP and MPV in the JS and OPP exercises was assessed on a customized Smith machine (adapted by Hammer Strength, Rosemont, IL, USA) and Multi-Hack equipment (Hammer Strength, Rosemont, IL, USA), respectively. The soccer players were instructed to execute 3 repetitions at maximal velocity for each load, starting at 40% of their body mass (BM) in the JS and 30% of their BM in the OPP. In the JS exercise, athletes executed a knee flexion until the thigh was parallel to the ground ($\approx 100^\circ$ knee angle for 2-s) and, after a command, jumped as fast as possible without losing contact between their shoulder and the bar
In the OPP exercise, athletes were required to start in the “rack position” (without countermovement) and accommodate the bar on the shoulders with the back of the arm parallel with the ground [24]. After a slight self-selected hip and knee flexion the athletes rapidly extended the hips and legs to generate upward momentum, and fully extend the arms to finish the movement with the bar overhead, in a full perpendicular trajectory (in relation to the ground) (Fig. 2). An experienced testing administrator visually validated all attempts, by verifying if the subjects properly performed both the JS and OPP. A load of 10% BM (in JS) and 5% BM (in OPP) was gradually added in each set until a decrease in MPP was observed. A 5-min interval was provided between sets. All athletes attained their maximum MPP (in both JS and OPP) during the execution of the tests, within 4–5 attempts. To determine MPP, a linear transducer (T-Force, Dynamic Measurement System; Ergotech Consulting S.L., Murcia, Spain) was attached to the Smith machine bar (in the JS) and the Olympic barbell (in the OPP). The finite differentiation technique was used to measure bar velocity and acceleration, presenting an associated error of <0.25%, while displacement was accurate to ±0.5 mm [42]. Instantaneous bar velocity was sampled at a frequency of 1000 Hz and, then, smoothed with a fourth-order low-pass Butterworth filter with a cutoff frequency of 10 Hz. A digital filter with no phase shift was subsequently applied to the data. The resolution of the A/D card is 14 bits. The displacement was obtained by integration of v data with respect to time; instantaneous acceleration (a) was obtained from differentiation of v with respect to time; instantaneous force (F) was calculated as F = m (a + g), where m is the moving mass (kg) and g is the acceleration due to gravity [15, 42]. The power was calculated as bar force multiplied by bar velocity, thus reflecting bar power [38]. As Sanchez-Medina et al. [42] demonstrated that mean mechanical values during the propulsive phase better reflect the differences in the neuromuscular potential between 2 given individuals, MPP rather than peak power was used in the JS and OPP. This approach avoids underestimation of true strength potential as the higher the mean velocity (and lower the relative load), the greater the relative contribution of the braking phase to the entire time spent in the upward phase of the jumping movement. The bar maximum MPP and the bar
MPV values obtained were considered for data analysis purposes. In order to consider the differences in the body mass between the athletes and avoid misinterpretation of the power outputs, these values were normalized by dividing the absolute power value by the body mass (i.e., relative power = W·kg⁻¹) (MPP REL).

Sprinting speed
5 pairs of photocells (Smart Speed, Fusion Equipment, AUS) were positioned at distances of 0, 5, 10, 20, and 30 m along the sprinting course, prior to the execution of the speed tests. The soccer players sprinted twice, starting from a standing position 0.3 m behind the starting line. In order to avoid weather influences, the sprint tests were performed on an indoor running track. A 5-min rest interval was allowed between the 2 attempts and the fastest time from the 2 attempts was retained for further analysis.

Zig-zag change of direction speed (COD speed test)
The COD course consisted of four 5 m sections marked with cones set at 100° angles, in an indoor court. The athletes were required to decelerate and accelerate as fast as possible without losing body stability. 2 maximal attempts were performed with a 5-min rest interval between attempts. Starting from a standing position with the front foot placed 0.3 m behind the first pair of photocells (i.e., starting line), the athletes ran and changed direction as quickly as possible, until crossing the second pair of photocells placed 20 m from the starting line. The fastest time from the 2 attempts was retained for further analysis.

Statistical analysis
Data were presented as mean ± standard deviation (SD) and 95% confidence interval (CI). The Shapiro-Wilk test was initially used to test the normality of data. To analyze the differences in the MPV, MPP, and MPP REL between the JS and OPP exercises, the differences based on magnitudes [3], and the paired t test were calculated (IBM SPSS Statistics, version 20). The quantitative chances for the JS or OPP exercises, using a confidence interval of 90%, having higher, similar or lower values were assessed qualitatively as follows: <1%, almost certainly not; 1% to 5%, very unlikely; 5% to 25%, unlikely; 25% to 75%, possible; 75% to 95%, likely; 95% to 99%, very likely; >99%, almost certain. If the chances of having better and poorer results were both >5%, the true difference was assessed as unclear. Magnitude-based inference was chosen since it allows the emphasis of effect magnitudes and estimate precision, focusing on non-effect interpretation rather than on absolute effect. In addition, the magnitude-based method defines the practical effect, allowing the researcher to qualify and/or quantify the probability of a worthwhile effect with inferential descriptors to aid interpretation. This analysis recognizes sample variability, and provides scientists and professional coaches with an indication of the practical meaningfulness of the outcomes. The spreadsheet available at: http://www.sportsci.org/index.html was used. Additionally, to determine the magnitude of the differences between the exercises, the effect size (ES: Cohen’s d) was calculated as the difference between OPP and JS mean testing scores divided by the mean SD of the OPP and JS exercises for each variable [11]. The ES magnitudes were interpreted using the thresholds proposed by Hopkins et al. [20], as follows: <0.2, 0.2–0.6, 0.6–1.2, 1.2–2, 2–4, and >4 for trivial, small, moderate, large, very large, and near perfect, respectively. A Pearson product-moment coefficient of correlation was used to analyze the relationships between MPP REL in the JS and OPP exercises and the velocity (VEL) in the linear and COD sprint tests and unloaded vertical jumping height (SJ and CMJ) (using IBM SPSS Statistics, version 20). The threshold used to qualitatively assess the correlations was based on Hopkins et al. [20], using the following criteria: <0.1, trivial; 0.1–0.3, small; 0.3–0.5, moderate; 0.5–0.7, large; 0.7–0.9, very large; >0.9 nearly perfect. The significance level was set as P<0.05. Coefficients of variation (CV) and intraclass correlation coefficients (ICCs) were used to indicate the absolute and relative reliability, respectively, for OPP and JS exercises (for MPV), SJ and CMJ (for vertical jumping height), and sprinting and COD tests (for mean VEL). The ICC and CV were 0.94 and 3.8% for OPP; 0.96 and 4.1% for JS; 0.96 and 3.1% for SJ; 0.94 and 3.5% for CMJ; 0.97 and 2.3% for 30-m speed; and 0.96 and 2.4% for the COD test.

Table 1
<table>
<thead>
<tr>
<th>Mean ± SD (cm)</th>
<th>CI (95 %) Upper</th>
<th>Lower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squat Jump</td>
<td>38.75±5.87</td>
<td>41.07</td>
</tr>
<tr>
<td>Countermovement Jump</td>
<td>39.77±6.01</td>
<td>42.15</td>
</tr>
<tr>
<td>Velocity 5 m (m·s⁻¹)</td>
<td>5.08±0.28</td>
<td>5.19</td>
</tr>
<tr>
<td>Velocity 10 m (m·s⁻¹)</td>
<td>5.88±0.28</td>
<td>6.01</td>
</tr>
<tr>
<td>Velocity 20 m (m·s⁻¹)</td>
<td>6.85±0.31</td>
<td>6.97</td>
</tr>
<tr>
<td>Velocity 30 m (m·s⁻¹)</td>
<td>7.38±0.33</td>
<td>7.51</td>
</tr>
<tr>
<td>Change of Direction Speed (m·s⁻¹)</td>
<td>3.62±0.13</td>
<td>3.67</td>
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</tbody>
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Table 2
<table>
<thead>
<tr>
<th>JS</th>
<th>OPP</th>
<th>ES (Rating)</th>
<th>Qualitative Inference</th>
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</thead>
<tbody>
<tr>
<td>MPV (m·s⁻¹)</td>
<td>1.04±0.09</td>
<td>1.65±0.22</td>
<td>3.96 (Very Large)</td>
</tr>
<tr>
<td>MPP (W)</td>
<td>698.0±113.1</td>
<td>727.0±134.8</td>
<td>0.23 (Small)</td>
</tr>
<tr>
<td>MPP REL (W·kg⁻¹)</td>
<td>9.42±1.56</td>
<td>9.78±1.69</td>
<td>0.22 (Small)</td>
</tr>
</tbody>
</table>

Results
All data presented normal distribution. Table 1 shows the descriptive data of the unloaded vertical jump tests (SJ and CMJ) and the VEL in the linear and COD sprint tests. The comparisons of the MPV, MPP, and MPP REL between the JS and OPP exercises are presented in Table 2. The MPV was almost certainly higher with a very large ES in the OPP than in the JS (P=0.01). Although not significant, the MPP and MPP REL were possibly higher with a small ES in the OPP compared to the JS (P=0.26 and P=0.30,
respectively) (Table 2). All the comparisons of MPP, MPV and MPP REL between JS and OPP resulted in statistical power of 81%.

Fig. 3 displays the correlations between the JS and OPP exercise outcomes (i.e., respective MPP REL values) and the VEL 5 m and VEL 10 m. Very large and significant correlations were found between the JS and VEL 5 m and VEL 10 m, while only moderate but significant correlations were observed between OPP and VEL 5 m and VEL 10 m (Fig. 3).

Fig. 4 depicts the correlations between the JS and OPP exercise outcomes and the VEL 20 m and VEL 30 m. The JS was very largely and significantly correlated to VEL 20 m and VEL 30 m. The OPP was moderately and significantly correlated to VEL 20 m and VEL 30 m (Fig. 4).

In Fig. 5 the correlations between JS and OPP exercise outcomes and the unloaded vertical jump tests (SJ and CMJ) are presented. Very large and significant correlations were found between the JS and the unloaded vertical jump tests, while moderate and significant correlations were observed between OPP and the SJ and CMJ (Fig. 5).

The COD speed test result was moderately correlated to the JS MPP REL ($r = 0.45$; 95% CI: 0.13–0.69; $P < 0.05$), while a trivial and non-significant association was observed between COD speed and OPP MPP ($r = -0.09$; 95% CI: -0.45–0.30). Finally, the JS MPP and the JS MPP REL were moderately correlated with the OPP MPP and the OPP MPP REL ($r = 0.45$; 95% CI: 0.13–0.72 and $r = 0.41$; 95% CI: 0.17–0.65, respectively; $P > 0.05$). Meanwhile, the correlation between the JS MPV and OPP MPV was rated as small ($r = 0.22$; 95% CI: 0.18–0.53; $P > 0.05$).
Discussion

This is the first study to test and compare the relationships between 2 different types of complex multi-joint exercises (i.e., the traditional JS and the OPP) and speed-power related abilities (i.e., jumping, sprinting and COD abilities) in elite soccer players. The main finding presented herein is that – contrary to our initial hypothesis – only the JS outcomes (i.e., MPP REL) presented very large and significant correlations with linear speed ($r > 0.7$, for speed in 5, 10, 20 and 30 m) and vertical jumping abilities ($r > 0.8$, for SJ and CMJ), and moderate correlation with COD speed ($r = 0.45$). Although significant, the associations between the OPP outcomes and linear speed, SJ and CMJ were all moderate, ranging from 0.40 to 0.48. On the other hand, a trivial and non-significant correlation was found between OPP MPP and COD speed ($r = -0.09$). Finally, the mean mechanical values assessed during the propulsive phase (i.e., MPV and MPP) in both the JS and OPP were (respectively) almost certainly and possibly higher in the OPP than in the JS.

Lake et al. (2014) argued that the mechanical demand of the push press is comparable with the JS exercise [24]. Additionally, it has been suggested that the OPP may provide an efficient combination of lower- and upper-body muscle power and strength, consequently increasing the resultant torque and mechanical impulse at the ankle, knee and hip joints [10, 24]. The data presented here are in agreement with these previous investigations, confirming that the OPP is capable of generating higher mechanical outcomes (i.e., MPP and MPV) than the JS. Although our power measurements were performed using a linear encoder attached to the barbell via a retractable cord, it was demonstrated that this OPP “extra-impulse” (generated simultaneously by both lower and upper limbs) may also enhance the mechanical bar outputs, thus potentially boosting these neuromuscular measures (in comparison to JS). Nevertheless, it appears that this “neuromechanical optimization” (i.e., capacity to generate higher levels of maximum muscle power) is not able to increase the level of associations between OPP and the lower limb speed-power related abilities. After analyzing our results, it is possible to suggest that – at least for jumping and sprinting capacities – the mechanical outcomes resulting from the leg power assessments (i.e., JS testing) are responsible for determining the strength of the associations between the laboratory measurements and the sport specific field tests (i.e., sprinting speed, SJ and CMJ height). Actually, the “power summation effect” delivered by simultaneously recruiting leg and trunk muscles might not provide immediate benefits to successfully execute lower limb motor tasks [24], possibly compromising the neuromechanical correlations investigated in this study. Obviously, these findings should be viewed with caution and further studies are still necessary to investigate the effects of this mechanical combination (between lower and upper body muscle power) on specific performance of high-level athletes.

Another potential advantage associated with the push press exercise (in comparison with the JS) is the absence of large impact forces during the landing phases of jumping, which might expose the athlete to an increased risk of overuse injury [21]. Certainly, this assumption must be tested in prospective investigations, since the external impact forces (during landings) in sport events are substantially higher than the impact forces inherent in plyometric and JS training [1, 22, 43, 45]. Furthermore, even if confirmed, it is possible to reduce the eccentric loading during the JS execution, using specific braking mechanisms or simply utilizing soft surfaces (that absorb a large amount of shock) during the landings [19, 21]. Conversely, the absence of jumping (and, consequently, of the flight phase) in the OPP conflicts with an important premise in determining specific sports performance: the mechanical relationship between an elite athlete and her/his body mass [29]. It is important to note that when a given subject performs a JS, she/he has to jump lifting up the “total mechanical system” (i.e., weighted bar + body mass), which necessarily implies neuromechanical outcomes (i.e., MPP and MPV) already adjusted for individual body mass. As a consequence, greater performances in JS do not only indicate larger values of relative muscle force and power, but additionally, greater capacity to accelerate one’s own body weight [4, 31]. It is highly plausible to suggest that these relative...
neuromuscular performance outcomes may be more related to the motor tasks executed without external/additional overloads, such as the short sprints (VEL 30 m) and the vertical jumps (SJ and CMJ) performed in this study.

From a general perspective, the results presented here are in line with a number of previous investigations reporting strong associations between the load capable of maximizing the power output in JS and speed-power related abilities [26,27,29,31,37,51]. The reasons behind these strong correlations are partially related to the similarity between the ballistic exercises (i.e., JS) and sprinting and jumping patterns, since they both allow projection and lifting of the subject, encompassing acceleration and deceleration phases [40,50]. On the other hand, the lack of applied studies indicating very large correlations between the Olympic lifts and practical field tests (i.e., SJ and CMJ) may be associated with the significant kinematic and kinetic differences between these types of exercise [7,46]. Thus, although some researchers have confirmed the effectiveness of Olympic lifts in improving functional performance [18,48], it is crucial to compare the effects of training using traditional ballistic exercises (i.e., JS) or Olympic lifts under optimum loading conditions. Especially as it has already been reported that traditional “triple-extension exercises” (i.e., segmental extension of the ankle, knee, and hip joints performed, for example, during squats or JS) performed using the loads that maximize the muscle power are capable of eliciting transference of strength-power gains to jump and sprint performance [33]. Curiously, the accepted belief that the concomitant multiple extension of upper and lower limbs increases muscle power outputs and (as a consequence) optimizes the transference of these positive neuromuscular adaptations to specific athletes’ performance, still needs to be validated. Importantly, as correlations do not necessarily imply cause and effect, the chronic effects of performing JS or OPP using the maximum power loads should be investigated through longitudinal studies.

The lower correlations between COD speed and the JS/OPP mechanical outputs (in relation to the linear speed tests), are possibly related to the complexity of this specific functional field assessment [6]. The zig-zag COD test consists of four 5 m sections (marked with cones set at 100° angles), in which athletes have to change direction quickly, accelerating as rapidly as possible in each section. Probably, the individual performance in COD speed assessments involves more physical and physiological components than muscle power, speed, and acceleration abilities [8,50]. These physical factors may have considerably weakened the associations between the exercise outcomes (i.e., MPP in JS and OPP) and the COD speed results.

We recognize as a limitation of this study the fact that our neuromechanical measurements were performed on the bar, and do not (necessarily) represent the total power generated during a given movement. However, as aforementioned, several studies have already reported very large associations between the JS optimum power loads (collected in the bar) and the field measurements [28,29,31]. Therefore, it is highly reasonable to consider that this range of loads may strengthen the relationships between some types of neuromuscular exercise (i.e., OPP) and complex motor tasks (i.e., jumps and sprints). In addition, complementary to the aim of this study, the strength-power exercises are always prescribed based on relative or absolute load measurements (i.e., optimal power load, percentage of body mass and 1-RM testing) [14,32,34,36], which reinforces the necessity to find a more effective range of loads for increasing functional performance in high-level athletes, with special consideration given to individual differences at the baseline [23]. Lastly, it is important to specify that the definition of the term “optimum load” in this study is related to the maximum muscle power outputs collected by a linear position transducer attached to the barbell (by measuring the bar MPV), which does not necessarily imply that this range of loads is more effective (in improving performance) than the maximum values of power assessed using other measurement devices (e.g., force plates).

Conclusion

To conclude, the data presented in this study do not support the idea that the OPP exercise is largely related to sports specific actions, such as vertical jumps and maximal short sprints. Based on our findings, from a cross-sectional perspective, it seems that the practical JS may be more indicated than the OPP for enhancing lower-limb neuromechanical abilities in team-sport athletes (i.e., soccer players). Analytically, this recommendation might be justified by the consistent correlations found between the JS mechanical outcomes and the neuromuscular assessments performed (sprinting speed [in all tested distances] and unloaded vertical jumps [SJ and CMJ]). From a practical standpoint, this suggestion might be raised in reference to the difficulty of learning/teaching a very complex neuromuscular training technique (i.e., Olympic lifting) to soccer players, who compete under a congested fixture schedule. Obviously, in high-level sports, when strong relationships between strength-power exercises and specific performance are found, all efforts should be made to insert these exercises in the athletes’ training program. However, at least for the moment, there is no scientific evidence to support the application of more complex exercises (e.g., OPP) in soccer, which focuses on improving sprinting and jumping abilities, due to the inherent match demands. Further studies should confirm these relationships in highly strength trained subjects (i.e., sprinters and jumpers) and also investigate/compare the correlations between OPP/JS and upper limb functional motor tasks (i.e., throwing and punching). Finally, longitudinal investigations should examine the chronic effects of training using Olympic lifts or the traditional JS and compare the possible transference of their respective strength-power gains to specific athletic performance.

Conflict of interest: The author have no conflict of interest to declare.

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