# Does sex impact the differences and relationships in the one repetition maximum performance across weightlifting overhead pressing exercises?

**ABSTRACT**

This study aimed to determine the impact of sex on the differences and relationships of the one-repetition maximum (1RM) performance between three overhead pressing exercises (push press, push jerk and split jerk). 15 males (body mass: 82.3 ± 9.9 kg; weightlifting training experience: 2.6 ± 1.6 years) and 15 females (body mass: 64.4 ± 7.0 kg; weightlifting training experience: 2.2 ± 1.4 years) participated in this study. A ratio scaled (1RM/body mass) was utilized for the comparison between males and females. The 1RM of the three exercises were evaluated within the same testing session using a combined 1RM assessment method. The interaction effect of exercise and sex did not reach statistical significance ($p=0.671$; $\eta^2=0.001$), whereas significant main effects of exercise and sex with medium ($p\leq0.01$; $\eta^2=0.096$) and large effect sizes ($p<0.001$; $\eta^2=0.306$) were revealed. A similar main effect of exercise was reported for both males (push press [1.0 ± 0.1] < push jerk [1.1 ± 0.2] ~ split jerk [1.2 ± 0.2]) and females (push press [0.8 ± 0.1] < push jerk [0.9 ± 0.2] ~ split jerk [0.9 ± 0.2]). The 1RM performance of the three exercises were significantly correlated for males (*r* [range] = 0.856-0.963) and females (*r* [range] = 0.636-0.925). These results suggest that sex does not impact the differences in the 1RM performance across weightlifting overhead pressing exercises. However, greater correlations and lower range variations in the 1RM performance during the push press, push jerk and split jerk are expected for males in comparison to females.

**KEYWORDS:** push press, push jerk, split jerk, maximal strength, females, correlations.

## INTRODUCTION

Accurate assessment of an individual's muscular strength is of great importance to researchers and practitioners as part of athlete-monitoring (16). The one repetition maximum (1RM) has typically been the preferred variable for assessing the maximal dynamic strength (3). Practitioners defend the use of the 1RM test for being highly reliable for untrained and trained individuals (5,20); highly applicable because it can be performed using the same exercises as those undertaken during training, and appropriate to differentiate between athletes of different training status and sporting disciplines (2,10,15). In addition, the 1RM test is easy to implement and requires relatively inexpensive equipment in comparison to other strength tests (e.g. isometric or isokinetic tests) (8).

Researchers have evidenced the need to assess different exercises to best capture the general strength levels of an individual (3,7). Consequently, based on the principle of specificity, various measures of strength have been commonly used to draw the strength profile of a given individual or sport groups. For example, Izquierdo et al. (10) measured the 1RM performance of the bench press and squat exercises in weightlifters, handball players, road cyclists, middle-distance runners, and a control group, demonstrating that weightlifters exhibited greater strength levels for both exercises in comparison to the rest of sport groups (bench press: $\geq$ 206 N and squat: $\geq$ 107.9 N; $p \leq 0.05$). Interestingly, handball players significantly outperformed road cyclists in the bench press (765.2 ± 127 N vs 539.5 ± 69 N; $p<0.05$), but no significant differences between these groups were reported for the squat (1334.0 vs 1314.5 N; $p>0.05$). These results further highlight the importance of assessing the strength of different exercises involving different muscle groups to differentiate athlete profiles in athletes of various disciplines.

A common practice in weightlifting is the measurement of maximal dynamic strength levels during the different exercises used by athletes in their regular training. This is useful to establish strength profiles, possible weaknesses and identify training priorities. For example, Hakkinen et al. (9) compared the 1RM during four exercises (snatch, power snatch, clean, and power clean) between seven male elite Finnish weightlifters (ELI) and six male district level weightlifters (DIS). They demonstrated significant differences in the 1RM between the snatch variations for the ELI (1RM snatch = 117.9 ± 22.1 kg, 1RM power snatch = 99.3 ± 18.4 kg, $p<0.001$) and DIS group (1RM snatch = 91.7 ± 16 kg, 1RM power snatch = 73.3 ± 12.9 kg, $p<0.001$). Similarly, significant differences in the 1RM were observed for both groups between the clean variations (ELI: 1RM clean = 150.7 ± 32.2 kg, 1RM power clean = 127.1 ± 25.1 kg, $p<0.001$; DIS: 1RM clean = 116.3 ± 24.2 kg, 1RM power clean = 100.8 ± 19 kg, $p<0.001$). In addition, there were significant between-group differences with the ELI group achieving higher 1RM values for the power snatch (99.3 ± 18.4 vs 73.3 ± 12.9 kg, $p<0.01$), snatch (117.9 ± 22.1 vs 91.7 ± 16 kg, $p<0.05$), power clean (127.1 ± 25.1 vs 100.8 ± 19 kg, $p<0.05$), and clean (150.7 ± 32.2 vs 116.3 ± 24.2 kg, $p<0.05$). However, no study has compared the 1RM performance between weightlifting exercises in females. What is more, to the authors' knowledge, no study has examined whether the sex can influence the differences and relationships of the 1RM performance between weightlifting derivatives.

Kelly et al. (12) compared the 1RM between three variations of the power clean (performed from the floor, knee and mid-thigh) in twelve healthy male subjects and demonstrated differences only in the power clean from the floor (93.3 ± 16.1 kg) which was significantly greater than from the knee (85.6 ±14.6 kg; $p=0.04$) and mid-thigh (86.1

± 17.6 kg; p=0.02). A further aim of this study was to determine the possibility of predicting the 1RM power clean performed from the knee and mid-thigh based on the 1RM power clean from the floor. A strong relationship was observed between the 1RM power clean from the floor and the 1RM power clean performed from the knee ($r=0.961$, $p<0.001$) and from the mid-thigh ($r=0.961$, $p<0.001$). Therefore, the authors concluded that it is possible to accurately predict the power clean 1RM performance performed from the knee and mid-thigh based on the power clean 1RM performed from the floor ($R^2>0.923$).

Although differences and relationships for the 1RM performance have been studied in healthy males for the clean and snatch variations (9,12), to the authors' knowledge, no study has focused on weightlifting overhead pressing derivatives (19). Weightlifting exercises as the push press (PP), push jerk (PJ) and split jerk (SJ) are powerful training tools to target the ability to develop force rapidly and therefore, enhance sport performance (19). Moreover, the impact of sex on the differences and relationships of the 1RM performance during overhead pressing derivatives remains unexplored. The aim of the present study was to determine the impact of sex on the differences and relationships of the 1RM performance between three overhead pressing exercises (PP, PJ and SJ). It was hypothesized that ratio scaled 1RM performance across the weightlifting overhead pressing exercises would not differ between males and females, since no evidence exists to support that notion. It was also hypothesized that the strength of the relationship for the 1RM obtained during the PP, PJ and SJ would be very high and comparable for males and females.

## METHODS

**Experimental approach to the problem**

A cross-sectional study was designed to compare the 1RM performance of three weightlifting overhead pressing exercises (PP, PJ, and SJ) in males and females. A ratio scaled 1RM (1RM/body mass [BM]) was utilized for the comparison between males and females, as previously suggested (6), due the large differences in body mass reported between them (Males: 82.3 ± 9.9 kg, females: 64.4 ± 7.0 kg). The 1RM of the three overhead pressing exercises were evaluated using the combined 1RM assessment method; a standardized protocol previously validated for overhead pressing exercises (ICC= 0.96 for PP, 0.98 for PJ, and 0.99 for SJ) (20). Verbal encouragement was provided throughout all maximal testing conditions. Subjects were asked to replicate their fluid and food intake 24 hours before the day of testing, to avoid strenuous exercise for 48 hours before testing, and to maintain any existing supplementation regimen throughout the duration of the study.

**Subjects**

An a priori power analysis was developed to calculate the sample size for the interaction of the ANOVA using G Power software (version 3.1.9.4, Heinrich Heine University, Düsseldorf, Germany); considering a $\eta^2$ medium effect size of 0.06 (F effect size = 0.25), an alpha of 0.05, a power level of 0.9, 2 groups, 3 measurements, and moderate correlations among repeated measures (r = 0.6). The power analysis determined a total sample size of 30 subjects with an observed statistical power level of 0.92. 15 males (age: 26.1 ± 5.0 years; height: 179.5 ± 5.6 cm; body mass: 82.3 ± 9.9 kg; weightlifting training experience: 2.6 ± 1.6 years) and 15 females (age: 27.5 ± 5.9 years; height: 167.5 ± 8.4 cm; body mass: 64.4 ± 7.0 kg; weightlifting training experience: 2.2 ± 1.4 years) took part in this study. Participants were amateur competitors in regional and national tournaments in CrossFit®, weightlifting, rugby union, track and field and volleyball.

Furthermore, they were required to have at least six months of weightlifting experience including the PP, PJ and SJ, performed regularly ($\geq$ 3 times per week) in their respective strength and conditioning training preparations. Participants had previously performed 1RM testing for a variety of exercises. The investigation was approved by the institutional review board of the University of Salford, and all participants provided written informed consent before participation. The study conformed to the principles of World Medical Association´s Declaration of Helsinki. Participants were supervised by a certified strength and conditioning specialist during the testing session to ensure appropriate technique.

**Procedures**

Subjects completed a warm up protocol which has been previously described by Soriano et al. (20). Briefly, the warm-up consisted of dynamic activation, exercise-specific drills, one set of 5 submaximal (50-60% of self-estimated 1RM) repetitions for each exercise (PP, PJ and SJ), and after 5 minutes of rest another set of 3 submaximal (70-85% of self-estimated 1RM) repetitions for each exercise. After the warm-up, subjects rested for 5 minutes before the start of the combined 1RM assessment method.

The combined 1RM assessment consisted of performing the 1RM test for the PP, PJ and SJ in a sequential order. The three exercises started from a near-maximal load (95% of self-estimated 1RM) and each successful attempt was followed by an increment of the load of 2.5-5.0% until the 1RM was reached, following previous NSCA guidelines (24). Subjects rested from 3 to 5 minutes between attempts within the same and different exercises. Hence, the 1RM in PP served as a preparation exercise for the PJ and both for the SJ, due to the fact that all of these exercises have a similar movement pattern (19,25). The barbell was taken out of power racks before starting each attempt to minimize the fatigue associated with the performance of the clean, which precedes the jerk in competitions (23). All testing sessions were performed using standardized barbells and plates (Werksan weights and Olympic bar; Werksan, Moorestown, New Jersey, USA), lifting platforms and power racks (Powerlift, Iowa, USA).

**Statistical Analyses**

Normality of the participant's characteristics (age, height, body mass and weightlifting experience) was confirmed for the males ($p>0.05$) but not for females ($p<0.05$). Therefore, the Mann-Whitney U test for independent samples was used to test between-group differences for the age, height, body mass and weightlifting experience.

Shapiro-Wilk's and Levene´s tests were used to determine the distribution and the homogeneity of variances of the 1RM performances, respectively. Greenhouse-Geisser correction was used when the assumption of sphericity was violated ($p<0.05$). A mixed repeated measures ANOVA with Bonferroni post hoc analysis was applied using the exercise (PP, PJ, and SJ) as within-subject factor, and group (males and females) as between subject-factor. An *a priori* alpha level was set at $p \leq 0.05$. Eta squared ($\eta^2$) were used to determine the magnitude of the effect independently of the sample size; $\eta^2$ has previously been recommended for ANOVA designs (14,17), and interpreted based on the recommendations of Cohen (4) (small < 0.06, medium = 0.06-0.14 and large ≥ 0.14). Furthermore, univariate scatterplots with 95% confidence intervals (CI) of the relative 1RM performance of the PP, PJ and SJ between males and females have been implemented for a more complete presentation of the data (26).

Pearson's correlations with 95% CI and coefficient of determination were also calculated between the PP, PJ and SJ to determine relationships between 1RM performances. An *a priori* alpha level was set at $p \leq 0.05$. The Pearson's correlation was interpreted based on the recommendations of Schober et al. (18) where $\leq$ 0.10 represents negligible correlation, 0.10-0.39 weak correlation, 0.40-0.69 moderate correlation, 0.70 to 0.89 strong correlation, and $\geq$ 0.9 very strong correlation.

## RESULTS

There were significant differences for the anthropometric measures (height and body mass; $p<0.001$), although no significant differences were found for age ($p=0.713$) or weightlifting experience ($p=0.567$) (**Table 1**).

**[Table 1]**

The results of the ANOVA revealed a significant main effect of exercise ($p\leq0.01$; SJ > PJ > PP) and sex ($p<0.001$; male > female) with medium ($\eta^2=0.096$) and large ($\eta^2=0.306$) effect sizes, respectively. However, the interaction of exercise and sex did not reach significance ($p=0.671$; $\eta^2=0.001$) with an observed statistical power level of 0.966. In males, Bonferroni post hoc analysis revealed significantly higher relative 1RM performance in the SJ (1.2 ± 0.2 kg/kg) and PJ (1.1 ± 0.2 kg/kg) compared to the PP (1.0 ± 0.1 kg/kg; both $p\leq0.001$), but no significant differences were reached between the SJ an PJ ($p=0.311$) (**Figure 1**). Similarly, females demonstrated significantly higher relative 1RM performance in the SJ (0.9 ± 0.2 kg/kg) and PJ (0.9 ± 0.2 kg/kg) compared to the PP (0.8 ± 0.1 kg/kg; both $p<0.001$), but no significant differences were observed between the SJ and PJ ($p=1.00$) (**Figure 1**). Males generally exhibited superior relative 1RM scores for all exercises in comparison to females (**Figure 1**, and **Figure 2**).

**[Fig 1]**

**[Fig 2]**

Males showed very strong correlations between the PP and the PJ ($r=0.902$, $p<0.001$) and between the PJ and SJ ($r=0.963$, $p<0.001$), while strong correlations were observed between the PP and the SJ ($r=0.856$, $p<0.001$) (**Figure 3**). Females revealed a very strong correlation between the PJ and SJ ($r=0.925$, $p<0.001$), a strong correlation between the PP and PJ ($r=0.767$, $p<0.001$), and a moderate correlation between the PP and the SJ ($r=0.636$, $p<0.05$).

**[Fig 3]**

## DISCUSSION

The main findings of this study were that the differences in the relative 1RM performance between the PP, PJ, and SJ are not affected by sex, whereas the relationships between the 1RM performance of these exercises are affected. The 1RM was higher for the SJ, followed by the PJ, and finally the PP. In line with this, males demonstrated higher 1RM values than females for all exercises. However, the novel finding of this study was the no significant interaction of exercise and sex, which indicates that the mentioned differences in 1RM values between the overhead pressing exercises do not differ between male and female athletes. These findings are important for strength and conditioning coaches because they describe the differences and relationships of the 1RM performance through the main weightlifting overhead pressing exercises (PP, PJ and SJ) for male and female athletes.

Researchers have previously compared the differences in the 1RM performance between the PP, PJ, and SJ in three well-trained male sport groups (CrossFit®, weightlifting and mixed sport group) (21). Only the weightlifters group was able to differentiate the 1RM between the three exercises (SJ>PJ>PP) ($p<0.001$), while no significant differences were observed in other groups between the PJ and SJ ($p>0.05$). The inclusion of athletes from different sport disciplines (CrossFit®, weightlifting, rugby union, track and field and volleyball) could explain the lack of differences observed in the present study between the PJ and SJ for both male and female groups (SJ~PJ>PP). These results reinforce the importance of the technical mastery on the differences between the SJ and PJ. Given that the displacement of the bar should be lower in the SJ than in the PJ (19), higher 1RM performances are expected for skilled lifters in the SJ, in line with the results of weightlifters (21). Nonetheless, although our subjects had previous experience with weightlifting exercises they were not (at least not all of them) skilled weightlifters where the discriminative role and technical mastery of the SJ is justified due to the high volume of repetitions performed in training and competitions (21–23).

To the authors' knowledge, this is the first study to compare the differences in three weightlifting overhead pressing exercises between males and females. For that comparison, a ratio scaling of the 1RM performance normalized to the body mass was used to diminish the big differences in body mass between males and females (6,11). In this study, males presented higher absolute (**Table 1**) and relative (**Figure 1**) 1RM performance than females for the PP, PJ and SJ. Although this finding has not been previously investigated for the weightlifting overhead pressing exercises, these results are in line with previous research that reported higher neuromuscular performance of males in comparison to females (1,11,13). For example, Jones et al. (11) found that males produced higher absolute average and peak power across a range of loads in the deadlift exercise ($p<0.001$). Similarly, Komi et al. (13) reported lower muscular power (-31.7%; $p<0.001$), total leg force (-19.7%; $p<0.001$), quadriceps force (29.0%; $p<0.001$) and force-time performance (50.3%; $p<0.001$) along with other physiological differences (i.e. muscle enzyme activities, electromyographic activity, muscle fiber composition, etc.) in a group of young females compared to their male counterparts. Furthermore, although it has been demonstrated that a long-term training may minimize the sex-related differences in neuromuscular function, the greater lean body mass of males would be ultimately promote their superior strength capacity (11). In addition, the results of this study provide a full description of data in Figure 3, where univariate scatter plots allow readers to examine data distribution and consider the characteristics of the data sets, rather than relying on the standard descriptive statistics (mean, SD, etc.) (26).

Strong correlations between the 1RM performance of the power clean from the floor and other two variations of the power clean (from the knee and mid-thigh) ($r\geq0.961$; $p<0.001$) were reported by Kelly et al. (12), with a resultant coefficient of determination indicating that 92.3% of the variance in the power clean from the knee and mid-thigh can be explained by the 1RM performance of the power clean from the floor. In line with this data, the present study reported for males strong (PP-SJ) and very strong correlations (PP-PJ and PJ-SJ) between the three weightlifting exercises. Females reported moderate (PP-SJ), strong (PP-PJ), and very strong (PJ-SJ) correlations between exercises. Interestingly, males reported higher coefficients of determination ($R^2\geq0.733$) in comparison to females

($R^2 \geq 0.404$). The strong relationships between the PP and PJ and between the PJ and the SJ for both groups may be based on the similar technical peculiarities reported in the dip (unweighting and braking phase of a quick partial squat) and drive (a very rapid propulsion via extension of the hips and knees and plantar flexion of the ankles) phases that share these exercises (19). On the other hand, the stronger relationships of males between the PP, PJ and SJ in comparison to females may be attributable to a higher absolute strength levels, where the absolute strength may play an important role for the consistency in the 1RM performance during the three exercises. However, in the case of females, as lower absolute strength levels have been reported, a greater relevance of the individual technical mastery is expected for the consistency in the 1RM performance.

Finally, the combination of sports disciplines may be a limiting factor in the generalizability of these findings. As previously demonstrated by Soriano et al. (21), there is a strong influence of the specificity principle in the 1RM performance explained by the interaction effect of exercise 1RM and sport group. Specifically, only weightlifters were able to discriminate the 1RM between the 3 exercises which is attributable to a higher technical mastery (21,23). The higher technical mastery of skilled weightlifters is justified by a higher volume of repetitions performed with weightlifting overhead pressing derivatives in training and competitions (21,23). Therefore, further research is guaranteed for comparisons of the variations in the 1RM performance between males and females in a long-term structured programme with different sport groups and exercises.

**PRACTICAL APPLICATION**

The present study provides evidence that sex does not impact the differences in the relative 1RM performance of the three main weightlifting overhead pressing exercises

(PP, PJ, SJ). However, the relationships are affected by sex with males showing stronger correlations between exercises (PP, PJ and SJ) in comparison to females. Strength and conditioning professionals should be aware of these results in order to prescribe adequate loads and choose the desired exercise for both sex. The SJ or PJ may be used interchangeably when attempting to increase maximal dynamic strength levels in males and females non-skilled weightlifters. Greater consistency in the 1RM performance during the PP, PJ and SJ is expected for males in comparison to females likely due to a greater relevance of absolute strength levels. In addition, the similar technical peculiarities of the dip and drive phases may be the main cause of the high correlations between the PP and PJ and between the PJ and the SJ for both groups.

**CONCLUSIONS**

There was a significant main effect of exercise and sex on the 1RM performance. Males reported significant higher ratio scaled 1RM performance than females in all exercises (PP, PJ and SJ). However, a similar main effect of exercise was reported separately for both male and female groups (SJ~PJ>PP) and the interaction of exercise and sex was not significant. These results suggest that sex does not impact the differences in the 1RM performance across weightlifting overhead pressing exercises. The strong correlations in the 1RM performance between the PP, PJ and SJ suggest that more consistency in the 1RM performance during the overhead pressing exercises are expected for males in comparison to females.

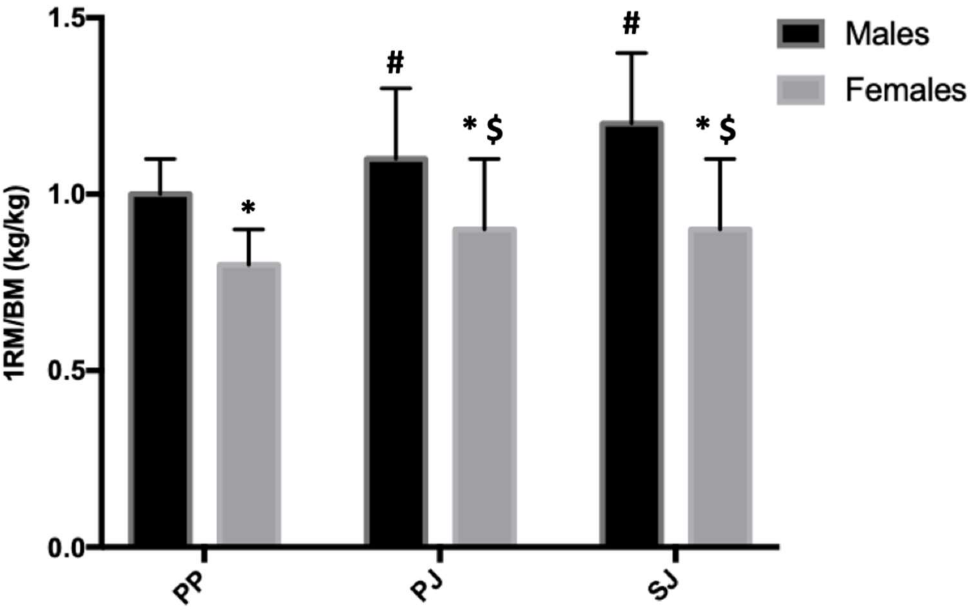


**Fig 1 .** Comparison of relative one repetition maximum performances between exercises and sex (mean ± *SD*). 1RM one repetition maximum, BM body mass, PP push press, PJ push jerk, SJ split jerk, * significantly ($p \leq 0.01$) lower than males' group, # significantly ($p \leq 0.001$) higher than males' PP, $ significantly ($p<0.001$) higher than females' PP.

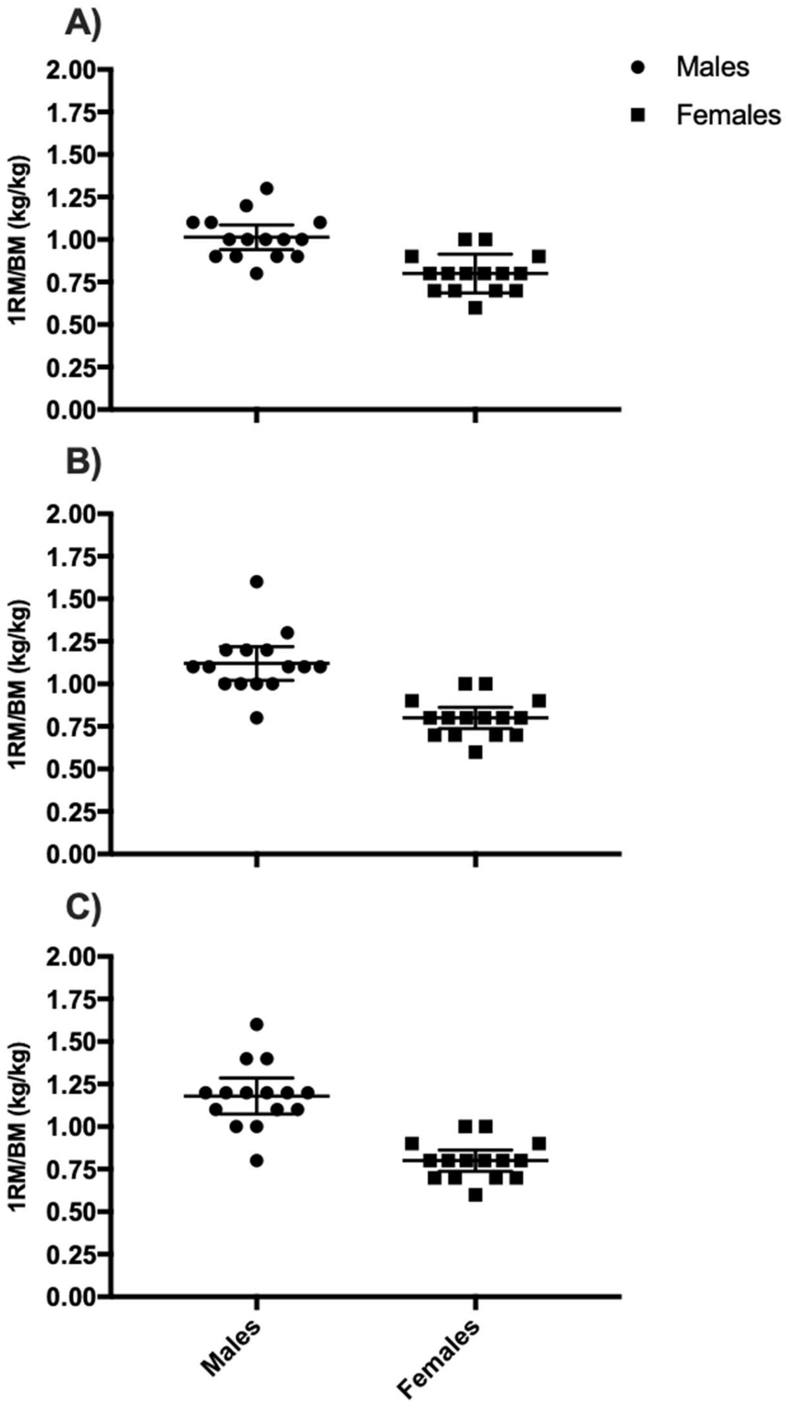


**Fig 2.** Univariate scatterplots of the relative one repetition maximum performance of the push press (A, upper panel), push jerk (B, middle panel) and split jerk (C, lower panel) between males and females (mean ± 95% CI). 1RM one repetition maximum, BM body mass.

**Table 1**. Descriptive characteristics of the groups

| Group | Sample size (n) | Age (years) | Height (cm) | Body mass (kg) | WL training experience (years) | 1RM PP (kg) | 1RM PJ (kg) | 1RM SJ (kg) |
|---|---|---|---|---|---|---|---|---|
| Males<br>(95% CI)<br>[range] | 15 | 26.1 ± 5.0<br>(23.3 to 28.9)<br>[from 19 to 35] | 179.5 ± 5.6<br>(176.3 to 182.6)<br>[from 172 to 190] | 82.3 ± 9.9<br>(76.8 to 87.8)<br>[from 62 to 97] | 2.6 ± 1.6<br>(1.7 to 3.5)<br>[from 0.5 to 6.5] | 82.2 ± 12.5<br>(75.3 to 89.1)<br>[from 60.0 to 102.5] | 91.8 ± 14.8<br>(83.6 to 100.1)<br>[from 65.0 to 125.0] | 97.0 ± 16.3<br>(87.9 to 106.1)<br>[from 67.5 to 127.5] |
| Females<br>(95% CI)<br>[range] | 15 | 27.5 ± 5.9<br>(24.2 to 30.7)<br>[from 21 to 41] | 167.5 ± 8.4*<br>(162.8 to 172.1)<br>[from 156 to 193] | 64.4 ± 7.0*<br>(60.5 to 68.3)<br>[from 53 to 84] | 2.2 ± 1.4<br>(1.5 to 3.0)<br>[from 0.8 to 4.5] | 50.8 ± 6.1*<br>(47.4 to 54.1)<br>[from 42.5 to 60.0] | 57.5 ± 8.0*<br>(53.1 to 61.9)<br>[from 40.0 to 70.0] | 60.3 ± 10.2*<br>(54.7 to 66.0)<br>[from 42.5 to 85.0] |

WL weightlifting, 1RM one repetition maximum, PP push press, PJ push jerk, SJ split jerk. *significantly ($p<0.001$) lower than the male's group

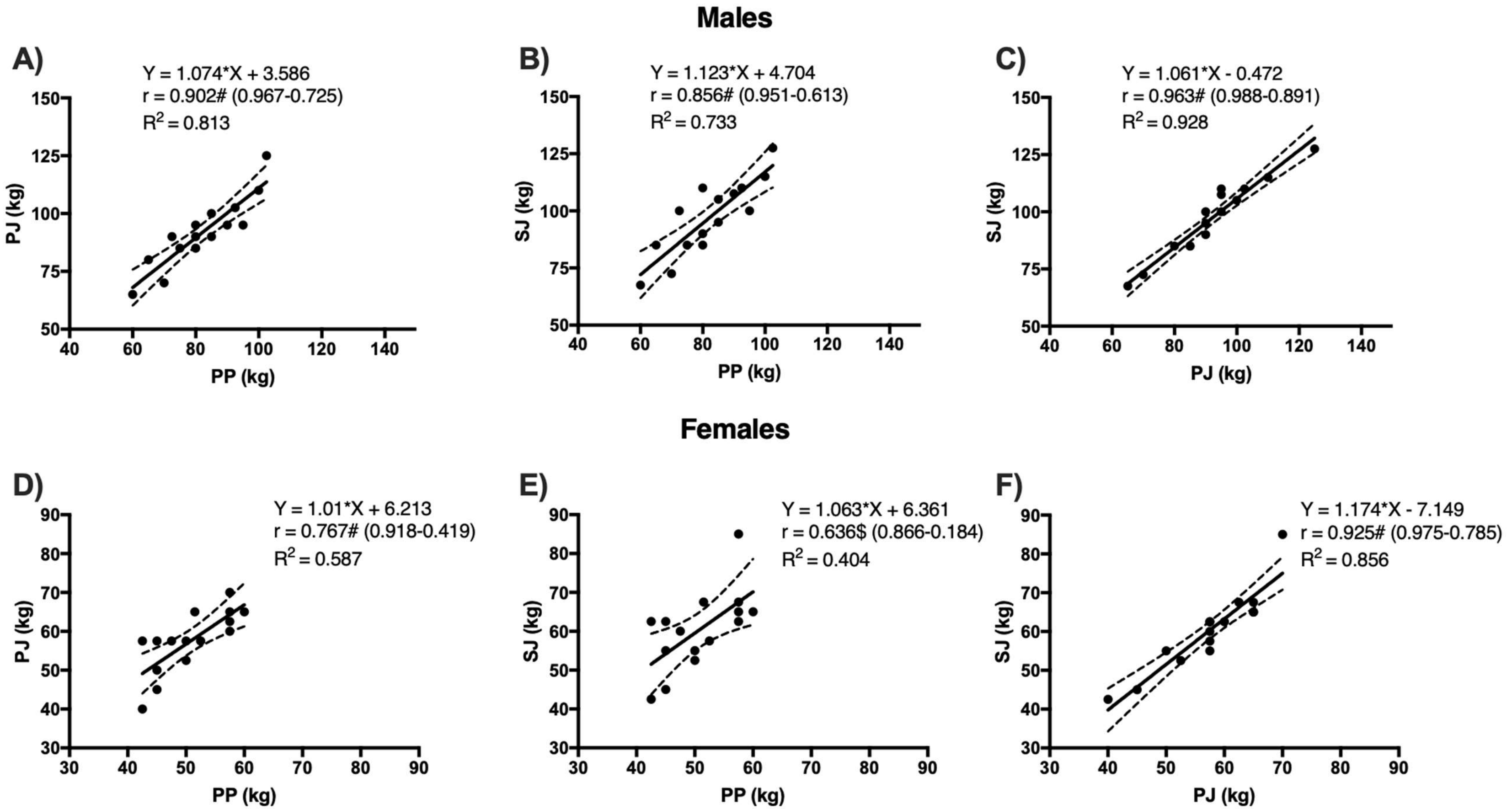


**Fig 3.** Relationships of the one repetition maximum (1RM) performance between the PP and PJ in females (A, upper left panel), PP and SJ in females (B, upper-middle panel), PJ and SJ in females (C, upper-right panel), PP and PJ in males (D, lower-left panel), PP and SJ in males (E, lower-middle panel), PJ and SJ in males (F, lower-right panel). PP push press, PJ push jerk, SJ split jerk, \$ $p<0.05$, # $p<0.001$. The regression model, Pearson's correlation coefficient ® with 95% confidence interval, and coefficient of determination ($R^2$) are depicted.

## REFERENCES


1. Askow, AT, Merrigan, JJ, Neddo, JM, Oliver, JM, Stone, JD, Jagim, AR et al. Effect of strength on velocity and power during back squat exercise in resistance-trained men and women. J Strength Cond Res 33: 1-7, 2019.
2. Baker, D. Comparison of upper-body strength and power between professional and college-aged rugby league players. J Strength Cond Res 15: 30-35, 2001.
3. Buckner, SL, Jessee, MB, Mattocks, KT, Mouser, JG, Counts, BR, Dankel, SJ, et al. Determining strength: a case for multiple methods of measurement. Sport Med 47: 193-195, 2017.
4. The analysis of variance and covariance: pp. 274-288 in Cohen J. Statistical power analysis for the behavioural science (2nd edition). Mahwah, NJ: Erlbaum, 1988.
5. Comfort, P and Mcmahon, JJ. Reliability of maximal back squat and power clean performances in inexperienced athletes. J Strength Cond Res 29: 3089-3096, 2015.
6. Comfort, P and Pearson, SJ. Scaling-which methods best predict performance? J Strength Cond Res 28: 1565-1572, 2014.
7. Cuk, I, Prebeg, G, Sreckovic, S, Mirkov, DM and Jaric, S. Generalization of muscle strength capacities as assessed from different variables, tests, and muscle groups. J Strength Cond Res 31: 305-312, 2017.
8. Dos'Santos, T, Thomas, C, Comfort, P, McMahon, JJ, Jones, PA, Oakley, NP, et al. Between-session reliability of isometric midthigh pull kinetics and maximal power clean performance in male youth soccer players. J strength Cond Res 32: 3364-3372, 2018.
9. Häkkinen, K and Kauhanen, H. A biomechanical analysis of selected assistant exercises of weightlifting. J Hum Mov Stud 12: 271-288, 1986.
10. Izquierdo, M, Häkkinen, K, González-Badillo, JJ, Ibáñez, J and Gorostiaga, EM.

Effects of long-term training specificity on maximal strength and power of the upper and lower extremities in athletes from different sports. Eur J Appl Physiol 87: 264-271, 2002.

11. Jones, M, Jagim, A, Haff, G, Carr, P, Martin, J and Oliver, J. Greater strength drives difference in power between sexes in the conventional deadlift exercise. Sports 4:43, 2016.
12. Kelly, JJ, McMahon, J and Comfort, P. A comparison of maximal power clean performances performed from the floor, knee and mid-thigh. J Trainology 3: 53-56, 2015.
13. Komi, PV and Karlsson, J. Skeletal muscle fibre types, enzyme activities and physical performance in young males and females. Acta Physiol Scand 103: 210-218, 1978.
14. Lakens, D. Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. Front Psychol 4: 863, 2013.
15. McBride, JM, Triplett-McBride, T, Davie, A and Newton, RU. A comparison of strength and power characteristics between power lifters, Olympic lifters, and sprinters. J Strength Cond Res 13: 58-66, 1999.
16. McMaster, DT, Gill, N, Cronin, J, and McGuigan, M. A brief review of strength and ballistic assessment methodologies in sport. Sport Med 44: 603-623, 2014.
17. Olejnik, S and Algina, J. Generalized eta and omega squared statistics: measures of effect size for some common research designs. Psychol Methods 8: 434, 2003.
18. Schober, P and Schwarte, LA. Correlation coefficients: Appropriate use and interpretation. Anesth Analg 126: 1763-1768, 2018.
19. Soriano, M, Suchomel, T and Comfort, P. Weightlifting overhead pressing derivatives: a review of the literature. Sport Med 49: 867-885, 2019.

20. Soriano, MA, García-Ramos, A, Torres-González, A, Castillo-Palencia, J, Marín, PJ and Comfort, P. Validity and reliability of a standardized protocol for assessing the one repetition maximum performance during overhead pressing exercises. J Strength Cond Res: epub ahead of print, 2020.
21. Soriano, MA, García-Ramos, A, Torres-González, A, Castillo-Palencia, J, Marín, PJ, Sainz de Baranda, P, et al. Comparison of one repetition maximum performance across three weightlifting overhead pressing exercises and sport groups. Int J Sports Physiol Perform: epub ahead of print, 2020.
22. Stone, MH, Pierce, KC, Sands, WA and Stone, ME. Weightlifting: Program design. Strength Cond J 28:10, 2006.
23. Storey, A and Smith, HK. Unique aspects of competitive weightlifting: Performance, training and physiology. Sport Med 42: 769-790, 2012.
24. Administration, scoring and interpretation of selected tests: pp. 249-273 in Baechle, TT and Earle, RW. Essentials of strength training and conditioning. Champaign, IL: Human Kinetics, 1997.
25. Waller, M, Piper, T, and Miller, J. Overhead pressing power/strength movements. Strength Cond J 31: 39-49, 2009.
26. Weissgerber, TL, Milic, NM, Winham, SJ, and Garovic, VD. Beyond Bar and Line Graphs: Time for a New Data Presentation Paradigm. PLoS Biol 13: e1002128, 2015.