Comparison of one repetition maximum performance across three weightlifting overhead pressing exercises and sport groups

ABSTRACT

Objective: This study aimed to (I) compare the one repetition maximum (1RM) performance between the push press (PP), push jerk (PJ) and split jerk (SJ), and (II) explore these differences between weightlifters, CrossFit® athletes and a mixed group of athletes. ***Method:*** Forty-six resistance trained male (age: 28.8 ± 6.4 years; height: 180.0 ± 6.0 cm; body mass: 84.1 ± 10.2 kg; weightlifting training experience: 3.64 ± 3.14 years) participated in this study. The 1RM performance of the PP, PJ and SJ were assessed during the same session in a sequential order (i.e. combined 1RM assessment method). Thirty-six participants were re-tested to determine between-session reliability of the 1RM values. ***Results:*** Intraclass correlation coefficients (ICC) and associated 95% confidence intervals showed a high between-session reliability for the PP (ICC = 0.98 [0.95-0.99]), PJ (ICC = 0.99 [0.98-1.00]) and SJ (ICC = 0.99 [0.98-1.00]). There was a significant main effect of exercise ($\eta^2 = 0.662$) and exercise x group interaction ($\eta^2 = 0.066$) on the 1RM performance ($p<0.0001$), while the main effect of group did not reach statistical significance ($p=0.072$). ***Conclusion:*** This study provides evidence that the weightlifting overhead pressing derivatives impact the 1RM performance. In addition, the interaction of exercise and sport group was caused by the higher differences in the 1RM performance between-exercises for weightlifters compared to CrossFit® and a mixed group of athletes. Therefore, strength and conditioning professionals should be aware that the differences in 1RM performance between weightlifting overhead pressing derivatives may be affected by the sport group.

Key words: push press, push jerk, split jerk, maximal strength, combined assessment

INTRODUCTION

High levels of muscular strength and power development are key to maximizing athletic performance.[1] Researchers currently suggest that greater muscular strength underpins many physical and performance attributes and can be vastly influential in the ability to generate high rates of force development (RFD) and high levels of power.[1,2] Furthermore, James et al.[3] found that improvements in performance of high velocity sporting actions are associated with pre-existing strength levels.

The one repetition maximum (1RM) is considered the gold standard for assessing the maximal strength during dynamic tasks.[4] The 1RM can be performed using the same exercises as those undertaken by the athletes during their regular training and is commonly used to prescribe the loads during resistance training programs.[5] The 1RM is frequently assessed by strength and conditioning professionals to compare the strength between sports and to monitor the changes in strength over time; however, only a few exercises such as the bench press, squat and power clean are commonly reported.[6,7] For example, McBride et al.[7] found that the 1RM performance in the squat exercise was able to discriminate the strength levels of weightlifters, powerlifters, sprinters and recreationally trained athletes ($p<0.05$). Of note is that the weightlifter's 1RM was significantly higher compared to sprinters 1RM ($p<0.05$) but no significant differences were observed compared to powerlifters ($p>0.05$).

The fact that the bench press, squat and power clean are the exercises most commonly used for assessing strength levels may lead to insufficient and inaccurate information to provide strength guidelines to various populations across numerous exercises included in resistance training programs. It has been suggested that multiple measurements of strength should be used to capture general strength adaptations of a given athlete.[4] It is important to note that there are notable differences in 1RM performances between exercises with similar kinematics. For example, Kelly et al.[8] compared the 1RM performance between three power clean variations (from the floor, from the knee and from mid-thigh) in twelve male collegiate athletes, reporting subtleties in exercise technique resulting in meaningful differences (>6%) in the 1RM performance. Similarly, Yavuz et al.[9] reported meaningful differences between the front and back squat variations with participants lifting significantly higher loads during the back squat compared to the front squat ($p<0.05$).

Researchers have suggested potential benefits for implementing overhead pressing derivatives as training tools to improve not only weightlifting performance, but also to enhance sports performance.[10] Notably, researchers have provided evidence that these exercises may be a time-effective method of enhancing lower-body strength and power; however, modifications in technical execution and equipment result in meaningful differences in force-time characteristics.[11,12] Therefore, the assessment of 1RM performance of different overhead pressing variations may provide valuable information to practitioners. To the authors' knowledge, there is little information regarding 1RM overhead pressing derivatives and no research has compared differences in 1RM between the main overhead pressing derivatives as the push press (PP), push jerk (PJ), and split jerk (SJ). Furthermore, it is important to note that although researchers have compared the 1RM performance between variations of the power clean,[8] they have not compared these exercise variations between athletes of different sporting backgrounds.

The main aim of this study was to compare the 1RM performance between three variations of overhead pressing (PP, PJ and SJ) for three different sport populations (weightlifters, CrossFit® athletes and a mixed group of athletes). A further aim of the study was to compare to 1RM performance of these variations across the three sport populations. Based on the evidence that the greatest force, velocity and power occur during the SJ,[10] it was hypothesized that, regardless of the sport population, the 1RM performance would be ranked from the highest to the lowest as follows: SJ, PJ and PP variation. Due to the higher predominance of overhead pressing derivatives in weightlifters' training routines,[13] it was also hypothesized that weightlifters would present the highest 1RM for these exercises.

METHOD

Subjects

Forty-six resistance trained males volunteered to participate in this study (Table 1). Participants were amateur competitors in regional and national tournaments in their respective disciplines. 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 were subdivided into three groups depending on their sport background: weightlifting, CrossFit®, and a mixed group of athletes (e.g. rugby league, rugby union, football, track and field, wrestling, gymnastic, volleyball and basketball). All 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 all testing sessions to allow familiarization with the protocols and ensure appropriate technique.

Experimental design

A within- and between-subjects design was adopted to determine the between session reliability of 1RM performance and to determine the differences in the 1RM performance across three weightlifting overhead pressing derivatives (PP, PJ and SJ), while also comparing across sport groups (weightlifters, CrossFit® and a mixed group of athletes). 46 healthy men were evaluated using the combined 1RM assessment method; a standardized protocol previously validated on a similar population for overhead pressing exercises [14]. In brief, the 1RM performance of the PP, PJ and SJ were assessed during the same session in a sequential order. 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). Furthermore, thirty-six participants performed the combined 1RM assessment method one week apart, to test the between-session reliability of the 1RM performance for each exercise. Verbal encouragement was provided throughout all maximal testing conditions. Participants were asked to replicate their fluid and food intake twenty-four hours before each day of testing, to avoid strenuous exercise for forty-eight hours before testing, and to maintain any existing supplementation regimen throughout the duration of the study. All testing was performed at the same time of day for all participants to minimize the effect of circadian rhythms.

Testing procedures

Participants completed a warm up protocol which has been previously described by Soriano et al.[14] Briefly, this consisted of dynamic activation, exercise-specific drills and one set of five submaximal (50-60% of the maximal perceived effort) repetitions in each exercise (PP, PJ and SJ). Five minutes of rest was taken, followed by another set of three submaximal (70-85% of the maximal perceived effort) repetitions for each exercise. After the warm-up, participants rested for 5 min before the start of the combined 1RM assessment method.

Measurement equipment and data analysis.

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 the maximal perceived effort) and each successful attempt was followed by a small increment of the load (2.5-5.0%) until the 1RM was reached, following previous NSCA guidelines.[15] Participants rested for 3 to 5 min between attempts within the same exercise and between-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.[10] 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.[16]

Statistical analyses

Descriptive data are presented as means and standard deviation (*SD*). To determine the between-session reliability of the 1RM assessment, the coefficient of variation (CV), intraclass correlation coefficient (ICC; model 3.1) and associated 95% confidence intervals (CI) were calculated and interpreted based on the recommendations of Cortina[17] where an ICC $\geq$ 0.80 is considered as highly reliable, while a CV < 15% was used as a criterion for the minimum acceptable reliability.[18] The reliability analysis was performed by means of a custom spreadsheet,[19] while SPSS (version 25.0: SPSS, Inc., Chicago, IL, USA) was used for the remaining analyses. Normality of the anthropometric measures (height and body mass) for each group was confirmed by the Shapiro-Wilk's ($p \geq 0.05$), while the age and weightlifting training experience were not normally distributed for weightlifters and mixed athlete groups ($p < 0.05$). Two one-way analysis of variance (ANOVA) with Bonferroni post hoc analysis were used to test between-group differences for the height and body mass, while the Kruskal-Wallis' test for independent samples was used to compare the age and weightlifting experience between groups.

Shapiro-Wilk's and Levene's tests were used to determine the distribution of the 1RM performances and the homogeneity of variances, respectively. The 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 exercises (PP, PJ, and SJ) as within-subject factor, and group (weightlifters, CrossFit®, and mixed athlete groups) as between-subject factor. An *a priori* alpha level was set at $p \leq 0.05$. Effect sizes were determined using eta squared (η^2) to determine the magnitude of the effect independently of the sample size; η^2 has previously been recommended for ANOVA designs,[20] and interpreted based on the recommendations of Cohen,[21] where effect sizes of < 0.06 are considered small, 0.06-0.14 are medium, and $\geq$ 0.14 are considered large effects.

RESULTS

The ICCs demonstrated high between-session reliability of the combined 1RM assessment for the PP (ICC = 0.98 [0.95-0.99]), PJ (ICC = 0.99 [0.98-1.00]) and SJ (ICC = 0.99 [0.98-1.00]). In addition, the low CV also confirmed the high reliability for the PP (CV = 2.45 % [1.99-3.20]), PJ (CV = 1.57 % [1.27-2.05]) and SJ (CV = 1.67 % [1.35-2.17]).

Participants characteristics' mean and *SD* (age, height, body mass and weightlifting training experience) are shown in Table 1. The results of the one-way ANOVA revealed no significant differences for the anthropometric measures (height and body mass), while the Kruskal-Wallis test revealed significant (p=0.004) differences for the age between-groups. The results of the Mann-Whitney U's test revealed that the CrossFit® group was significantly (p=0.004) older than the weightlifters and the mixed group of athletes. In addition, no differences were found for weightlifting training experience between groups.

Table 1. Descriptive characteristics of the groups

Group	Sample size (n)	Age (years)	Height (cm)	Body mass (kg)	WL training experience (years)
WL [range]	15	26.4 ± 1.6 [from 19 to 40]	177.9 ± 1.8 [from 166 to 193]	81.1 ± 3.1 [from 62 to 108]	4.5 ± 1.3 [from 0.5 to 20]
CF [range]	19	32.1 ± 1.1* [from 22 to 42]	180.4 ± 1.3 [from 169 to 191]	83.4 ± 2.0 [from 68 to 99]	3.3 ± 0.3 [from 1 to 7]
MX [range]	12	26.2 ± 2.1 [from 20 to 43]	182.1 ± 1.2 [from 174 to 190]	88.9 ± 2.5 [from 77 to 105]	3.2 ± 0.6 [from 0.8 to 7.5]

WL = weightlifting , CF = CrossFit® athletes, MX = mixed group of athletes, *significantly (p=0.004) higher than the WL and MX group

The results of the ANOVA revealed a significant main effect of exercise and exercise x group interaction on the 1RM performance with medium and small effect sizes, respectively. However, for the combined 1RM performances there were no significant differences between groups with an observed power of 0.918 (Table 2).

Table 2. ANOVA's results of comparing within- and between-subjects' effects on the 1RM performance

Exercise	Group			Main effect		Interaction
	WL	CF	MX	Group	Exercise	Exercise x Group
PP (kg)	94.7 ± 17.6	86.1 ± 13.8	90.4 ± 14.8			
PJ (kg)	105.5 ± 17.9	93.0 ± 14.0	97.1 ± 17.4	**F = 1.8** p **= 0.175** η^2 **= 0.066**	**F = 105.6** p **< 0.001** η^2 **= 0.101**	**F = 6.0** p **< 0.001** η^2 **= 0.012**
SJ (kg)	115.3 ± 21.2	96.6 ± 16.3	102.9 ± 18.3			

PP = push press, PJ = push jerk, SJ = split jerk, WL = weightlifters, CF = CrossFit® athletes, MX = mixed group of athletes, F = F value, p = significance value; η^2 = eta squared

Weightlifters demonstrated significantly higher 1RM SJ performance (115.3 ± 21.2 kg) compared to the PJ (105.5 ± 17.9 kg; p<0.001) and PP (94.7 ± 17.6 kg; p<0.001). The

CrossFit® group demonstrated significantly higher 1RM SJ performance (96.6 ± 16.3 kg) compared to the PP (86.1 ± 13.8 kg; $p<0.001$), but not significant than the PJ (93 ± 14 kg; $p=0.90$). The mixed group of athletes demonstrated significantly higher 1RM SJ performance (102.9 ± 18.3 kg) compared to the PP (90.4 ± 14.8 kg; $p<0.001$), but not significantly greater than the PJ (97.1 ± 17.4 kg; $p=0.110$) (Fig 1).

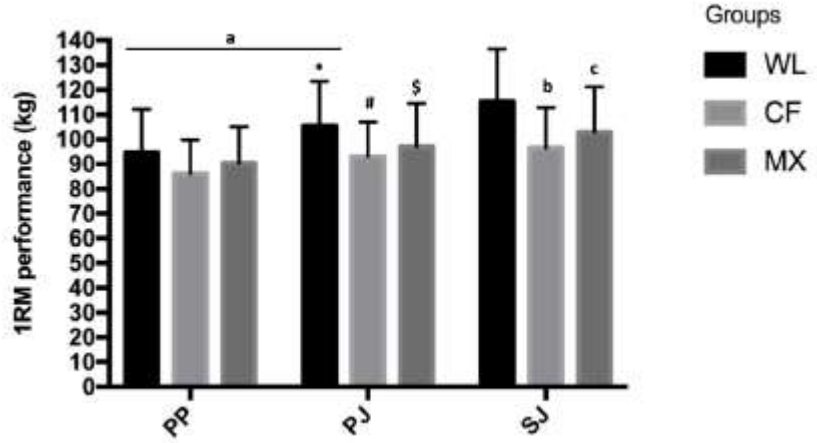

Figure 1. Comparison of one repetition maximum performances between exercises and between groups, PP push press, PJ push jerk, SJ split jerk, WL weightlifters, CF CrossFit® athletes, MX mixed group of athletes, a significantly ($p<0.001$) lower than the WL-SJ, b significantly ($p<0.001$) greater than the CF-PP, c significantly ($p<0.001$) greater than the MX-PP, *significantly ($p<0.001$) greater than the WL-PP, # Significantly ($p<0.001$) greater than CF-PP, $ significantly ($p=0.028$) greater than MX-PP.

DISCUSSION

The main finding of this study was that a significant effect of exercise was found on the 1RM performance in line with our previous hypothesis, however, there was no significant effect of group. These findings are important for strength and conditioning coaches because they describe not only the variations of the 1RM performance through the main overhead pressing derivatives (PP, PJ and SJ), but also how these variations occurred in different sport groups. In addition the ICC and CV showed a high between-session reliability for the three exercises in line with previous results.[14]

As hypothesized, the SJ was the exercise where the heaviest loads were lifted for the three groups, followed by the PJ and PP. However, for the CrossFit® athletes and the mixed group there were no significant differences for the 1RM performance between the PJ and SJ. This 1RM performance sequence was expected based on the notion that the jerk provides a greater stimulus for force, velocity and power production.[10,22] The differences in the 1RM performance may be attributable to the technical peculiarities of each exercise variation as previously stablished for the power clean.[8] According to this, although the three exercises share the same lower-body propulsion pattern (composed by the dip, breaking and thrusting phases), there are important differences between the PP, PJ and SJ at the end of the propulsion phase. Mainly, in the PP the lifter must continue pressing the barbell with the upper body (flexion of the shoulders and extension of the elbows) to reach the overhead position in a continuous motion;[23] on the other hand, when the barbell leaves the shoulders during the PJ and SJ the lifter must drop under the barbell in either a ¼ squat (PJ) or split position (SJ) to catch the barbell overhead.[24] Therefore, the SJ and

PJ are clearly advantageous to lift greater loads as less barbell displacement and therefore mechanical work is required to receive the barbell overhead.[10,24]

The groups included in this study represent 3 different sport populations based on their competitive disciplines. Previously, researchers found that maximal strength levels of the lower body extremities may discriminate the long-term adaptations of the training specificity in athletes from different sports.[7,25] For example, Izquierdo et al.[25] found that a weightlifting group was differentiated in comparison to other sport groups (e.g. handball players, middle-distance runners, road cyclists and a control group), by their higher 1RM performance in the half squat; however, McBride et al.[7] found that 1RM performance was able to differentiate weightlifters vs. sprinters and a control group, but not from the powerlifters. Since the training routines of both weightlifters and powerlifters usually implement heavy squats, it seems that the training specificity plays a major role of the training adaptations and therefore, the 1RM performance of a given exercise is influenced by such training background. In the present study, all participants had weightlifting training experience and no statistical differences in weightlifting training experience were found between groups. Although there were no significant differences in the 1RM performance between groups, the weightlifters showed a trend to have higher 1RM performances for the three exercises in comparison to the other groups. However, our results show that the PP, PJ and SJ were not able to discriminate between groups as previously stated for the squat.[7,25] Note that differences in training experience were based on years of training, however the hours of training and practice in the weightlifters are likely to be substantially higher than in other groups.

A clear interaction effect between exercises and sport group was found in the present study. For example, the weightlifters' SJ was the most discriminative exercise as this presented the biggest difference in performance between the three groups; however, no significant differences were found between the PJ and SJ for the CrossFit® and the mixed group of athletes. Although these differences may be attributable to a wide range of physiological and psychological factors,[16,26,27] these results support the specificity training principle[7,25] and the theory of Buckner et al.[4]. The theory of Buckner et al.[4] reflects that the 1RM performance assessment (test) is a highly specific sporting task, which means that the more the practice, the better the performance.[4] Due to that the SJ is highly trained by weightlifters and is part of official weightlifting competitions,[13,16] its discriminative role only for the weightlifters group is justified.

Finally, the training status may be a limiting factor in the generalizability of these findings.[4,28] Note that although the three groups can be considered as well-trained athletes due to the specified resistance training background of $\geq$ 2 years,[29] they may otherwise be classified as recreationally trained based on the recommendations of Rhea.[30] Therefore, more research is needed to elucidate how world class and more experienced participants than those used for this study may impact the 1RM performance during the PP, PJ and SJ.

PRACTICAL APPLICATION

The present study provides evidence that the main weightlifting overhead pressing derivatives impact the 1RM performance. Strength and conditioning professionals should be aware of these differences in order to prescribe the loads adequately and choose the

desired exercises. The SJ may be more favourable when attempting to increase the maximal strength levels in weightlifters, followed by PJ and PP. However, CrossFit® and the mixed group of athletes may use the SJ and PJ interchangeably when the objective is to increase the maximal strength levels. Furthermore, this research extends the specificity principle due to the interaction effect of exercise (PP, PJ and SJ) and sport group on the 1RM performance. Specifically, weightlifters presented higher differences in the 1RM performance between-exercises (9-22%), in comparison to the CrossFit® group (4-11%) and the mixed group of athletes (6-14%). Therefore, practitioners should be aware of differences in the 1RM performance between weightlifting overhead pressing derivatives may be affected by the sport group. This study provides preliminary evidence for future research into a comparison of the variations in the 1RM performances in a long-term structured programme, where the training specificity of each group may have a greater impact.

CONCLUSIONS

There is an effect of exercise on the 1RM performance during the main weightlifting overhead pressing derivatives (PP, PJ and SJ). The SJ is the exercise where the greatest loads were lifted for the three sport groups assessed; however, it was not significantly greater for the CF and MX groups in comparison to the PJ. In addition, the interaction of exercise and sport group revealed that the sport group impacted the 1RM performance with weightlifters showing the largest differences in 1RM performance between exercises.

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REFERENCES

1. Suchomel TJ, Nimphius S, Stone MH. The importance of muscular strength in athletic performance. *Sport Med*. 2016;46:1419-1449.
2. Stone MH, Moir G, Glaister M, Sanders R. How much strength is necessary? *Phys Ther Sport*. 2002;3:88-96.
3. James LP, Haff GG, Kelly VG, Connick MJ, Hoffman BW, Beckman EM. The impact of strength level on adaptations to combined weightlifting, plyometric, and ballistic training. *Scand J Med Sci Sport*. 2018;28:1494-1505.
4. Buckner SL, Jessee MB, Mattocks KT, et al. Determining strength: a case for

multiple methods of measurement. *Sport Med*. 2017;47:193-195.
5. Banyard HG, Nosaka K, Haff GG. Reliability and validity of the load-velocity relationship to predict the 1RM back squat. *J Strength Cond Res*. 2017;31:1897-1904.
6. McMaster DT, Gill N, Cronin J, McGuigan M. A brief review of strength and ballistic assessment methodologies in sport. Sport Med. 2014;44:603-623.
7. Mcbride JM, Triplett-Mcbride T, Davie A, Newton RU. A comparison of strength and power characteristics between powerlifters, Olympic lifters, and sprinters. *J Strength Cond Res*. 1999;13:58-66.
8. Kelly J, J. McMahon J, Comfort P. A comparison of maximal power clean performances performed from the floor, knee and mid-thigh. *J Trainology*. 2015;3:53-56.
9. Yavuz HU, Erdağ D, Amca AM, Aritan S. Kinematic and EMG activities during front and back squat variations in maximum loads. *J Sports Sci*. 2015;33:1058-1066.
10. Soriano MA, Suchomel T, Comfort P. Weightlifting overhead pressing derivatives: a review of the literature. *Sport Med*. 2019;49:867-885.
11. Winwood PW, Cronin JB, Brown SR, Keogh J. A biomechanical analysis of the strongman log lift and comparison with weightlifting's clean and jerk. *Int J Sports Sci Coach*. 2015;10:869-886.
12. Renals L, Lake J, Keogh J, Austin K. Strongman log push press: the effect log diameter has on force-time characteristics. *J Strength Cond Res*. 2018;32:2693-2700.
13. Stone MH, Pierce KC, Sands WA, Stone ME. Weightlifting: program design. *Strength Cond J*. 2006;28:10-17.
14. Soriano MA, García-Ramos A, Torres-González A, Castillo-Palencia J, Marín PJ, Comfort P. Validity and reliability of a standardized protocol for assessing the one repetition maximum performance during overhead pressing exercises. *J Strength Cond Res*. 2019. Epub ahead of print.
15. Baechle TR, Earle RW. Essentials of strength training and conditioning (3rd edition). Human kinetics, 2008.
16. Storey A, Smith HK. Unique aspects of competitive weightlifting: performance, training and physiology. *Sport Med*. 2012;42:769-790.
17. Cortina JM. What is coefficient alpha? An examination of theory and applications. *J Appl Psychol*. 1993;78:98.
18. Baumgartner TA, Chung H. Confidence limits for intraclass reliability coefficients. *Meas Phys Educ Exerc Sci*. 2001;5:179-188.
19. Hopkins W. Calculations for reliability (Excel spreedsheet). A new view of statistics, 2000.
20. Lakens D. Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. *Front Psychol*. 2013;4:863.
21. Cohen J. Statistical power analysis for the behavioral science (2nd edition). Routledge, 1988.
22. Garhammer J. A comparison of maximal power outputs between elite male and female weightlifters in competition. *Int J Sport Biomech*. 1991;7:3-11.
23. Bishop C, Chavda S, Turner A. Exercise technique: the push press. *Strength Cond J*. 2018;40:104-108.
24. Waller M, Piper T, Miller J. Overhead pressing power/strength movements. *Strength Cond J*. 2009;31:39-49.
25. Izquierdo M, Häkkinen K, Gonzalez-Badillo JJ, Ibáñez J, 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*. 2002;87:264-271.
26. Abernethy P, Wilson G, Logan P. Strength and power assessment: issues, controversies and challenges. *Sport Med*. 1995;20:205.
27. Suchomel TJ, Nimphius S, Bellon CR, Stone MH. The importance of muscular strength: training considerations. *Sport Med*. 2018;765-785.
28. Ritti-Dias RM, Avelar A, Salvador EP, Cyrino ES. Influence of previous experience on resistance training on reliability of one-repetition maximum test. *J Strength Cond Res*. 2011;25:1418-1422.
29. Cormie P, McGuigan MR, Newton RU. Influence of strength on magnitude and mechanisms of adaptation to power training. *Med Sci Sports Exerc*. 2010;42:1566-1581.
30. Rhea MR. Determining the magnitude of treatment effects in strength training research through the use of the effect size. *J Strength Cond Res*. 2004;18:918-920.

FIGURE CAPTIONS

Figure 1. Comparison of one repetition maximum performances between exercises and between groups, PP push press, PJ push jerk, SJ split jerk, WL weightlifters, CF CrossFit® athletes, MX mixed group of athletes, a significantly ($p<0.001$) lower than the WL-SJ, b significantly ($p<0.001$) greater than the CF-PP, c significantly ($p<0.001$) greater than the MX-PP, *significantly ($p<0.001$) greater than the WL-PP, # Significantly ($p<0.001$) greater than CF-PP, $ significantly ($p=0.028$) greater than MX-PP.