THE JOURNAL OF SPORTS MEDICINE AND PHYSICAL FITNESS
EDIZIONI MINERVA MEDICA

Determinant factors of pull up performance in trained athletes

MIGUEL SANCHEZ MORENO, Fernando PAREJA-BLANCO, David DíAZ-CUELI, JUAN JOSE GONZALEZ-BADILLO

J Sports Med Phys Fitness 2015 Jul 15 [Epub ahead of print]

THE JOURNAL OF SPORTS MEDICINE AND PHYSICAL FITNESS
Rivista di Medicina, Traumatologia e Psicologia dello Sport
pISSN 0022-4707 - eISSN 1827-1928
Article type: Original Article

The online version of this article is located at http://www.minervamedica.it

Determinant factors of pull up performance in trained athletes

Miguel Sánchez-Moreno[1], Fernando Pareja-Blanco[1], David Díaz-Cueli[2], Juan José González-Badillo[1]

[1]Physical and Athletic Performance Research Centre, Department of Sport, Pablo de Olavide University, Seville, Spain

[2] Real Club Deportivo Espanyol, Barcelona, Spain.

Acknowledgments

No funding was received for this work from any institution. The authors declare no conflicts of interest

Corresponding author

Miguel Sánchez-Moreno.

Pablo de Olavide University.

Physical and Athletic Performance Research Centre, Department of Sport.

Road Utrera, Km 1.

41013 Seville, SPAIN.

E-mail: msanmor@hotmail.com

Abstract

Aim: to investigate the relationship among pull up and lat pull exercises and different anthropometric dimensions in trained athletes.

Methods: twenty-five males were evaluated for maximum number of pull ups, one-repetition maximum lat pull (1RM Lat Pull), lat pull repetitions at 80% 1RM (Lat Pull at 80% 1RM), lat pull repetitions at a load equivalent to body mass (Lat Pull at BM-load), and different anthropometric variables. Furthermore, the subjects were divided in higher (HPG, n = 12) and lower pull up performance (LPG, n = 13) to compare the differences in the variables analyzed between both levels.

Results: pull ups were significantly correlated with Lat Pull at BM-load (r = .62, P < .01) but neither with 1RM Lat Pull (r = .09) nor with Lat Pull at 80% 1RM (r = -.15). Pull ups showed a significant (P < .05) negative relationship with body mass (BM, r = -.55), lean body mass (LBM, r = -.51), and fat mass (FM, r = -.52), while BM and LBM were significantly correlated with 1RM Lat Pull (r = .55, P < .05). HPG showed significantly (P < .05) lower BM (0/3/97%), FM (1/3/97%) and LBM (1/4/95%) than LPG. Furthermore, HPG attained significantly (P < .05 – .001) greater performance in Lat Pull at BM-load (100/0/0%) and 1RM Lat Pull•BM^{-1} (96/3/2%) than LPG.

Conclusion: these findings suggest that pull up and lat pull exercises have common elements. Moreover, the anthropometric dimensions seem to influence differently on both exercises, depending on the strength indicator evaluated.

Keywords: Resistance exercise - Strength assessment - Body composition - Lat pull.

Determinant factors of pull up performance in trained athletes

Introduction

Resistance training (RT) is recognized not only as an effective method for increasing strength, power and muscle hypertrophy, it can also be equally effective in improving individual health status. Configuration of the exercise stimulus in RT has been traditionally associated with a combination of the resistance exercise variables such as load, number of sets and repetitions, exercise type and order, rest duration, repetition velocity etc.[1] Hence, the selection of exercise might determine the magnitude and type of physiological responses and adaptations to RT.[2] The pull up and the latissimus dorsi pull (lat pull) are two exercises commonly used to increase upper-body muscular pulling strength. The pull up is a calisthenic, multi-joint upper-body exercise,[3] which is considered a valid measure of weight-relative muscular strength.[4] In the pull up, the individual grips a stationary bar overhead and pulls the body mass (BM) upward to the bar. The individual is typically limited to the use of BM as resistance, although external load can be added via a weighted vest or belt to achieve greater resistance.[5] The lat pull is a resistance exercise consisting of a shoulder adduction and an elbow flexion.[6] A specially designed machine allows the subject to sit with support across the thighs to stabilize the lower body while pulling a horizontal bar downward from an extended overhead arm position, allowing the addition of external load to achieve the desired degree of resistance loading.[5,7]

The pull up has traditionally been used to test upper-body strength to BM ratio in children, adolescents, and men and women attending the U.S. military service academies.[3,8] Additionally, the need to lift one´s BM is obvious in certain occupational settings, such as law enforcement, military, and firefighting.[9,10] Williford *et al.*[10] found that the best model to predict the time to complete physical performance assessment consisting in forcible entry, hoist, hose advance, victim rescue, and stair climb included pull ups, a 1.5 mile run, and fat-free weight.

Intuitively pull up and lat pull exercises appear to involve the same muscles performing similar motions. Hence, both exercises might be considered interchangeable in a training program. However, few studies have examined the relationship between them.[5,11,12] These studies were focused on comparing maximum pull up repetitions to one-repetition maximum (1RM) lat pull and lat pull maximal repetitions at 60% and 80% 1RM. These studies did not observe significant relationships between these variables and suggested that the seemingly analogous exercises of pull up and lat pull should not be substituted for one another in a training regimen. Nevertheless, Halet *et al*.[12] found a moderate significant relationship ($r = .69$) between 1RM lat pull per kg of BM and pull ups. On the other hand, Chandler *et al*.[11] observed that maximum repetitions in lat pull exercise using 60% 1RM were related to 1RM lat pull ($r = .46$) but not to pull ups ($r = .05$). Furthermore, unweighted pull ups were not significantly related to 1RM lat pull ($r = -.01$). In such study,[11] only when pull up repetitions was combined with BM, 1RM lat pull could be predicted ($r = .72$). To the best of our knowledge, no study has included a direct measure of the strength relative to BM in the lat pull exercise. Thereby, it seems appropriate to include it for further explorations of the relationships between these two exercises.

In addition, the influence of selected anthropometric and body composition variables in similar calisthenic and resistance exercises has been studied.[5,12,13] Pull up and lat pull seem to be influenced differently by anthropometric and body composition variables. Halet *et al*.[12] and Johnson *et al*.[5] observed significant negative relationships between pull up and several fitness measures including BM, lean body mass (LBM), and fat mass (FM).

Furthermore, a previous study[14] reported that an excess in BM, simulating body fat, greatly decreased the ability to perform pull ups, suggesting that body fat, more than total BM, affects the pull up performance. Moreover, Johnson *et al.*[5] also found that 1RM lat pull exhibited significant positive relationships with BM, LBM and FM. However, these degrees of relationship were studied in subjects with low and moderate pull up performance. For example, Johnson *et al.*[5] analyzed the relationships among 1RM in lat pull, 1RM in pull up and repetitions to muscular failure using 80% 1RM in both lat pull and pull up. In such study,[5] none of the average college women could perform a single pull up repetition against BM. Considering the limitations of the aforementioned studies, it would be advantageous to the strength and conditioning specialist to determine the degree of association between these two exercises in highly trained athletes. Therefore, the purpose of this study was to determine the relationships between pull up repetitions and different strength assessments in lat pull exercise and different anthropometric variables in a group of trained athletes. A second purpose was to determine the differences between the subjects with higher and lower pull up performance in the different strength and anthropometric variables assessed.

Material and Methods

Participants

Twenty five men volunteered to take part in this study (mean ± SD: age 26.8 ± 6.3 yr, height 176.2 ± 5.3 cm, body mass 70.9 ± 7.1 kg, percent fat 11.5 ± 1.0%, percent muscle mass 48.7 ± 1.4%). Subjects were either firefighters or policeman candidates who performed the same resistance training during the 8 months prior to this study, where pull ups and lat pulls were commonly used. All participants provided written informed consent and were screened for medical contraindications prior to testing. The study was conducted in accordance with the Declaration of Helsinki II.

Experimental procedure

This study used a cross-sectional experimental design to compare the anthropometric and body composition qualities and pull up and lat pull performance of trained athletes. In the preceding 2 weeks, two preliminary familiarization sessions were undertaken with the purpose of emphasizing proper execution technique in the different tests assessed. An anthropometric assessment was performed during the familiarization sessions. The sessions took place at a neuromuscular research laboratory under the direct supervision of the investigators and under constant environmental conditions (20 ºC, 60% humidity). As the time of day can influence on performance,[15] all tests were conducted within the same time range, from 17:00 to 21:00 h. All tests were performed in 3 testing sessions separated by 48-72 h, which were conducted in the following order: 1) pull up testing; 2) 1RM lat pull testing and repetitions to muscular failure in lat pull against a load equivalent to 80% 1RM test (Lat Pull at 80% 1RM); and 3) repetitions to failure in lat pull against a load equivalent to BM test (Lat Pull at BM-load). Before the tests were performed, the subjects underwent a 15-minute standardized warm-up period, which consisted of jogging, shoulder movements and 2 submaximal sets of the testing exercise directed by the primary researcher along with the coach. During the execution of these tests, the subjects were verbally encouraged to give their maximal effort. The tests executed for the assessment of performance are explained in detail below.

Measures

The 1RM Lat Pull was performed using a seated lat pull machine (Steelflex PLLA, Taiwan) with support across the top of the quadriceps. The seat was adjusted to allow the subject to start the movement with the arms fully extended. A self-selected width with pronated grip was used throughout the testing, however, due to the changes observed in the electrical activity of specific muscles caused by the different handgrip position during the lat pull exercise,[16] the subjects were asked to use a similar grip width (approximately 150% of the bi-acromial distance). Each repetition started with the arms fully extended and was completed when the bar was below the chin.[17] A warm-up using 2 submaximal sets of 5-10 repetitions at 60-70% of the estimated 1RM was given before testing. After a 5 min recovery, a mass load was selected based on the judgment of the lifter and the investigator, and 1 repetition was performed. If the attempt was successful, the mass load was increased by 2.5 to 5 kg depending on the ease of completing a single repetition, and 5 min rest was given before another single repetition was attempted.[5,18] This procedure was followed until a complete repetition was not possible. 1RM was reached in 4-6 attempts. The intraclass correlation coefficient (ICC) of this testing method has previously been noted to range from 0.95 to 0.99.[19,20] Relative strength to BM in this exercise was calculated (1RM Lat Pull·BM^{-1}). After 5 min rest, a Lat Pull at 80% 1RM test was performed. This test was performed using the same device with a load that represented the 80% 1RM, which was previously measured in this exercise. The subjects completed the maximum number of repetitions to task failure with a maximum pause of 2 s between repetitions.[21]

After a 2-3 days recovery period, lat pull maximal repetitions were performed on the same device using a load equivalent to BM (Lat Pull at BM-load). The warm-up and the procedures were identical to the one described for the 1RM lat pull. The subjects completed the maximum number of repetitions to task failure with a maximum 2 s pause between repetitions.[21] All loads lifted by the subjects were within 1 kg based on the BM.

The pull ups were performed on a standard stationary, horizontal bar. To be counted as a complete pull up, it was required that subject lifted his body from a full-arm extension hanging position (approximately same width pronated grip than in the lat pull test) until the chin was above the bar. The subjects were instructed to complete the maximum number of free-hanging pull ups with a maximum 2 s pause between repetitions[21]. Half repetitions were counted if the subject was able to reach a position of 90 degrees of flexion at the elbow.[12] All participants completed an identical 10 min warm-up including shoulder movements and 2 submaximal sets of pull ups. The reliability of a typical pull up test has been reported to be between 0.92 and 0.95 ICC.[14,21]

Height was measured during a maximal inspiration with a precision of 0.5 cm using a stadiometer (Quirumed, Valencia, Spain). BM was determined using a calibrated digital scale (Tanita, BC-543, Tokyo, Japan) with the subjects wearing only underwear. Skinfolds thicknesses were measured with a Holtain LTD lipocaliper (Crymych, United Kingdom) (range 0–40 cm; resolution 0.2 mm at a pressure of 10 $g \cdot mm^{-2}$ across the full opening range). The skinfolds measured were the tricipital, subscapular, abdominal, suprailiac, anterior thigh, and mid leg. The exact positioning of each skinfold measurement was in accordance with the procedure described previously.[22] Bone diameters (biepicondyle of the humerus and the bicondyle of the femur) were measured using a pachymeter (range 1–250 mm; resolution 1 mm). The circumferences of the contracted brachial biceps and the calf muscle were measured using a nonstretch, flexible metallic tape (resolution 1 mm). All measurements were made in duplicate by the same trained operator. If the differences between the two values were less than 5%, the average value of both measurements was used for analysis. When the differences exceeded 5% we performed a third measure and the average value of the three measurements was used. Percent Fat was estimated using the Faulkner equation[23] [Percent Fat (%) = (tricipital+ subscapular + suprailiac + abdominal skinfolds x 0.153) + 5.783]. Fat mass (FM) was calculated as BM · Percent Fat · 100^{-1}, and lean body mass (LBM) was determined as BM – FM**.**22 Muscular Mass (MM) was estimated using the Matiegka equation[24] [MM (kg) = BM – (FM + Bone Mass + Residual Mass)]. Percent MM was calculated as MM · BM^{-1} · 100.

Statistical Analyses

Descriptive statistics are expressed as mean ± SD. The distribution of each variable was verified by Shapiro-Wilk normality test. Linear regressions with Pearson's coefficients (r) and 90% confidence intervals (90% CI) were used to calculate the respective relationships between the performance parameters analyzed. To isolate the possible effect of BM on physical performance, these relationships also were adjusted with partial correlations. Multiple stepwise linear regression analyses were used to determine the degree to which any variable accounted for a significant variation in pull up and 1RM Lat Pull performances. In multiple regression analysis, standardized beta weights were used to evaluate the relative contribution of each independent variable in explaining the overall variance. In order to compare the differences between the variables analyzed between high and low pull up performance levels, the subjects were divided in high and low performance group in pull up (HPG, n = 12; and LPG, n = 13), with respect to the mean of the entire group. A one-factor ANOVA was used to analyze these differences. In addition, the standardized difference or effect size (ES) between groups in each variable was calculated using the pooled pre-training SD.[25] Uncertainty in each effect was expressed as 90% CI and as probabilities of the true effect being substantially positive and negative. These probabilities were used to make a qualitative probabilistic mechanistic inference about the true effect: if the probabilities of the effect being substantially positive and negative were both >5%, the effect was reported as *unclear*; if the effect was otherwise clear it was reported as the magnitude of the observed value. The scale was as follows: 25 − 75%, *possibly*; >75 − 95%, *likely*; >95 − 99%, *very likely*; >99%, *most likely*.[26] The probability level of statistical significance was set at $P \leq .05$.

Inferential statistics based on the interpretation of the magnitude of effects were calculated using a purpose-built spreadsheet for the analysis of controlled trials.[27] The rest of statistical analyses were performed using SPSS software version 18.0 (SPSS Inc., Chicago, IL).

Results

Table I shows the relationship among pull up and lat pull performances and anthropometric qualities. Significant relationships ($P < .01$) were observed between pull up and Lat Pull at BM-load ($r = .62$ [.41 to .83]), and pull up and 1RM Lat Pull·BM^{-1} ($r = .57$ [.33 to .79]). No significant relationships were observed between pull up and Lat Pull at 80% 1RM ($r = -.14$ [-.47 to .19]) and 1RM Lat Pull (.09 [-.24 to .42]). However, when BM and LBM were controlled statistically the relationship between pull up and 1RM Lat Pull were increased ($r = .56$ [.33 to .79], $P < .01$; and $r = .51$ [.26 to .76], $P < .05$). BM ($r = -.55$ [-.78 to -.32]), FM ($r = -.52$ [-.76 to -.28]) and LBM ($r = -.50$ [-.75 to -.25]) showed significant relationships ($P < .01 - .05$) with pull up, whereas Percent Fat and Percent MM did not show any relationship (**Table I**). 1RM Lat Pull showed significant relationships ($P < .01$) with Lat Pull at 80% 1RM ($r = -.55$ [-.78 to -.32]), 1RM Lat Pull·BM^{-1} ($r = .71$ [.54 to .88]), BM ($r = .55$ [.32 to .78]), and LBM ($r = .55$ [.32 to .78]). No significant relationships were observed between 1RM Lat Pull and Lat Pull at BM-load, FM, Percent Fat, and Percent MM (**Table I**).

Table I about here

The stepwise regression analysis yielded a two-variable equation for estimating pull up performance. The selected variables were BM and 1RM Lat Pull. The equations to predict pull up performances were as follows:

$$\text{Pull up} = .34 \times \text{BM} + .72 \times \text{1RM Lat Pull} + 29.37 \quad (R = .72,\ R^2 = .52,\ P < .01)$$

The coefficient of determination expressed as a percentage indicated that 52% of the variance in pull up was accounted for the variance of BM and 1RM Lat Pull. The standard error of estimate (SEE) for the equation was 2.4 repetitions and the coefficient of variation (CV) was 15%.

The stepwise regression also revealed that pull ups and LBM were the best predictor of 1RM Lat Pull. 1RM Lat Pull prediction is expressed by the following equation:

1RM Lat Pull (kg) = 2.93 x LBM + 3.83 x pull ups – 87.8 ($R = .69$, $R^2 = .48$, $P < .05$)

The SEE for the equation was 19.9 kg and the CV was 12%. Forty-eight percent of the variance in 1RM Lat Pull was accounted for the variance in pull ups and LBM. When the subjects were dichotomized according to their pull up performance, HPG had significant ($P < .05$) lower BM, FM, and LBM than LPG. No significant differences were observed between groups for Percent Fat and Percent MM (**Table II**). HPG showed significant ($P <.05 – .001$) greater performance in Lat Pull at BM-load and 1RM Lat Pull·BM^{-1} than LPG. However, no significant differences were observed between groups for 1RM Lat Pull and Lat Pull at 80% 1RM (**Table II**). Furthermore, HPG showed *very likely-likely* lower BM, FM, LBM and Percent Fat than LPG, whereas the differences in Percent MM were *unclear* (**Fig. 1**). On the other hand, HPG showed greater performance in Lat Pull at BM-load (100/0/0%) and 1RM Lat Pull·BM^{-1} (96/3/2%) than LPG. The differences for 1RM Lat Pull and Lat Pull at 80% 1RM were *unclear* (**Fig. 1**).

Table II about here

Figure 1 about here

Discussion

To our knowledge this is the first study to investigate the relationship between the relative strength to BM in lat pull exercise and pull up performance. One of the main findings of this study was that pull up performance showed significant relationships with different strength measures in lat pull exercise with respect to BM (Lat Pull at BM-load and 1RM Lat Pull·BM^{-1}), whereas the strength assessment without considering BM did not show any relationship with pull up performance (1RM Lat Pull and Lat Pull at 80% 1RM). In addition, the relationships observed between pull up and anthropometric variables suggest that there is an influence of absolute values of BM, FM and LBM on pull up performance, whereas the relative values (Percent Fat and Percent MM) do not seem to account for the performance in pull up in highly trained athletes. Therefore, pull up and lat pull might be considered as analogous and interchangeable exercises provided that the load in lat pull exercise is normalized to athlete´s BM.

An important and unique finding of this study is that there exists a significant correlation (P < .01) between pull up performance and Lat Pull at BM-load (r = .62 [.41 to .83]). To our knowledge, the relationship between the number of repetitions to task failure against a load equivalent to BM in lat pull exercise (Lat Pull at BM-load) and pull up performance had not been investigated yet. In addition, we also observed a significant relationship (P < .01) between pull up performance and 1RM Lat Pull·BM^{-1} (r = .57 [.33 to .79]). This latter finding is in accordance with that reported by Halet *et al*.[12] who observed a similar relationship between both variables (r = .69). The similar relationships observed between pull up and lat pull performance relative to BM (Lat Pull at BM-load and 1RM Lat Pull·BM^{-1}) might be explained by the fact that greater relative strength to BM (1RM Lat Pull·BM^{-1}) means that a load equivalent to BM (Lat Pull at BM-load) represents a lower relative effort. Consequently, a greater number of repetitions might be performed with this load. This suggestion is supported by the relationship observed between Lat Pull at BM-load and 1RM Lat Pull·BM^{-1} (r = .53 [.29 to .77], P < .05, **Table I**).

On the other hand, in the current study no significant relationship was observed between pull up and 1RM Lat Pull and Lat Pull at 80% 1RM, in according with previous studies.[5,11,12] Based on the results collected, these authors[5,11,12] concluded that the seemingly analogous exercises of pull ups and lat pulls should not be substituted for one another in a training regimen because both exercises were not related. However, we suggest that this lack of association might be partially explained by the fact that 1RM Lat Pull and Lat Pull at 80% 1RM alone cannot be considered as an indicator of relative strength to BM as the pull up. In our study, when lat pull exercise was combined with BM (Lat Pull at BM-load and 1RM Lat Pull•BM^{-1}) showed significant relationship with pull up (**Table I**). This suggestion is backed by the increase in the relationship between pull up and 1RM Lat Pull when BM was controlled statistically (from .09 to .56). In addition, we observed that pull up could be predicted (R^2 = .52) only when 1RM Lat Pull were combined with BM. Other studies[11,12] observed that 1RM Lat Pull could be predicted accurately only when pull up repetitions were combined with BM or LBM. In this regard, we observed that although pull ups alone were not significantly correlated with 1RM Lat Pull (r = .09), combining them with LBM increased the accuracy of predicting 1RM Lat Pull substantially (R = .69, SEE = 19.9 kg, CV = 12%). Thus, the present study suggests that pull up and lat pull are analogous exercises when common factors as BM and LBM are taken into account, as it has been shown by the relationships observed between pull up performance and Lat Pull at BM-load and 1RM Lat Pull·BM^{-1}, by the partial correlation between pull up and 1RM Lat Pull when BM, LBM were controlled and by the best predictors of pull ups and 1RM Lat Pull performances. These results may have some practical relevance for maximizing gains in pull up performance since lat pull allows a better adjustment and individualization of the training load. Thus, lat pull might be used as complement of pull up training aiming to maximize gains in maximal strength and muscular endurance in pull up exercise.

Moreover, the influence of the body composition on pull up and lat pull performances appears to exert opposite effects on the different measures of strength (maximum or relative to BM) in both exercises. We observed that 1RM Lat Pull was positively related to BM and LBM, whereas, pull up performance, Lat Pull at BM-load and 1RM Lat Pull•BM^{-1} showed negative relationships with BM, LBM, and FM (**Table I**). In accordance with our results, Halet *et al.*[12] also found that pull up was inversely related to BM (r = -.47), LBM (r = -.43) and FM (r = -.44) whereas 1RM Lat Pull showed a positive relationship to BM (r = .38) and LBM (r = 0.41). Similar results were observed by Johnson *et al.*[5] who observed a positive relationship between 1RM Lat Pull and BM and LBM (r = .47, and r = .55; respectively). The latest also found positive relationships between 1RM pull up and BM and LBM (r = .42 and r = .67; respectively).[5] Therefore, these results suggest that absolute values of maximum strength in both exercises (1RM Lat Pull, and 1 RM pull up) may be favored by higher BM and LBM whereas that relative to BM strength values (Lat Pull at BM-load, and pull ups) might be negatively influenced by higher BM, LBM and FM. Likewise, we observed that when the subjects were divided by their pull up performance, HPG showed lower values of BM, FM, and LBM than LPG (**Table II**). Similar results were observed by Halet *et al.*[12], showed significant lower values of BM, LBM, and FM in high strength lat pull groups (≥1.0 kg•kg BM^{-1}). The fact of greater amounts of BM, FM and LBM were in detrimental to pull up performance agrees with the findings of other investigators[5, 11, 12] and it suggests that heavier athletes might penalty for relative strength values, however, this heavier mass might suppose a benefit for absolute strength performance.

Considering the above results, extreme care should be taken with fatness and BM when the aim of the training is to improve pull up performance. Flanagan *el al.*[9] observed that the best predictor of pull up success at the end of 12-week strength and conditioning program included the participant´s initial percent fat. However, in our study, no differences were observed in percent fat between HPG and LPG (**Table II**). This fact could be explained by the characteristics of the population studied. Being trained athletes, both groups presented a low percent fat, with a trend towards lower value in HPG but without reaching statistically significant differences (**Table II**). These results may have relevance to assess the fitness level of those professions that require carrying heavy equipment and request certain physical demands like lifting his or her BM. On the other hand, in professions like firefighter, a sudden increase in total mass caused by the use of specific equipment[28] would have a negative influence over the capacity to lift one´s BM, especially in those with lower BM. Special care should be taken in the absolute values of maximum strength in pulling and pushing exercises to ensure success in specific tasks like forcible entry, hoist, hose advance and victim rescue.

Conclusion

In conclusion, these findings suggest that pull up and lat pull exercises have common elements. On the other hand, the anthropometric dimensions and body composition variables seem to exert a different influence on both exercises depending on the strength indicator evaluated. For example, heavier BM, even if it is mostly LBM, may invoke a certain penalty on pull up and Lat Pull at BM-load performance, but could have a positive effect on 1RM Lat Pull. As a limitation of the present study, the anthropometric variables were estimated using a skinfold prediction equation.[21] This fact should be kept in mind when interpreting our results. However, this method has been previously chosen[7] because it is a more reasonable method to use in a field setting (as opposed to dual energy x-ray absorptiometry or underwater weighing). To conclude, although previous authors[5,12] state that the seemingly analogous exercises of pull ups and lat pulls should not be substituted for one another in a training regimen, the relationships observed in the present study between pull up performance and Lat Pull at BM-load and 1RM Lat Pull·BM^{-1}, the increase observed in the relationship between pull ups and 1RM Lat Pull when BM and LBM were controlled statistically and the main predictor of pull up and 1RM Lat Pull performances revealed by the multiple regression analysis suggest that pull up and Lat Pull are analogous exercises when body composition factors as BM and LBM are taken in account. These findings are relevant for strength and conditioning coaches since pull up requires minimal skill and equipment, whereas lat pull would allow a better adjustment and individualization of the load during the training program. This aspect might be a key factor for maximizing maximal strength and muscular endurance gains for many athletes and professionals who require perform activities like climbing ropes and poles, swimming, rowing/paddling, gymnastics, and wrestling.

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript

References

1. Kraemer WJ, Ratamess NA. Fundamentals of Resistance Training: Progression and Exercise Prescription. Med Sci Sports Exerc 2004; 36 (4): 674-688

2. Spiering BA, Kraemer WJ, Anderson JM, Armstrong LE, Nindl BC, Volek JS, et al. Resistance exercise biology: manipulation of resistance exercise programme variables determines the responses of cellular and molecular signalling pathways. Sports Med 2008; 38 (7): 527-540

Ronai P, Scibek E. The Pull-up. Strength Cond J 2014; 36 (3): 88-90
4. Pate RR, Burgess ML, Woods JA, Ross JG, Baumgartner T. Validity of field tests of upper body muscular strength. Res Q Exerc Sport 1993; 64 (1): 17-24
5. Johnson D, Lynch J, Nash K, Cygan J, Mayhew JL. Relationship of lat-pull repetitions and pull-ups to maximal lat-pull and pull-up strength in men and women. J Strength Cond Res 2009; 23 (3): 1022-1028
6. Lusk SJ, Hale BD, Russell DM. Grip width and forearm orientation effects on muscle activity during the lat pull-down. J Strength Cond Res 2010; 24 (7): 1895-1900
7. Harman EA, Gutekunst DJ, Frykman PN, Nindl BC, Alemany JA, Mello RP, et al. Effects of two different eight-week training programs on military physical performance. J Strength Cond Res 2008; 22 (2): 524-534
8. Youdas JW, Amundson CL, Cicero KS, Hahn JJ, Harezlak DT, Hollman. JHSurface electromyographic activation patterns and elbow joint motion during a pull-up, chin-up, or perfect-pullup™ rotational exercise. J Strength Cond Res 2010; 24 (12): 3404-3414
9. Flanagan S, Vanderburgh P, Borchers S, Kohstall C. Training college-age women to perform the pull-up exercise. Res Q Exerc Sport 2003; 74 (1): 52-59
10. Williford HN, Duey WJ, Olson MS, Howard R, Wang N. Relationship between fire fighting suppression tasks and physical fitness. Ergonomics 1999; 42 (9): 1179-1186
11. Chandler T, Ware J, Mayhew J. Relationship of lat-pull repetitions and pull-ups to 1-RM lat-pull strength in male athletes. J Human Mov Studies 2001; 41 (1): 25-38
12. Halet KA, Mayhew JL, Murphy C, Fanthorpe J. Relationship of 1 repetition maximum lat-pull to pull-up and lat-pull repetitions in elite collegiate women swimmers. J Strength Cond Res 2009; 23 (5): 1496-1502
13. Esco MR, Olson MS, Williford H. Relationship of push-ups and sit-ups tests to selected anthropometric variables and performance results: A multiple regression study. J Strength Cond Res 2008; 22 (6): 1862-1868
14. Vanderburgh PM, Edmonds T. The effect of experimental alterations in excess mass on pull-up performance in fit young men. J Strength Cond Res 1997; 11 (4): 230-233
15. Chtourou H, Hammouda O, Souissi H, Chamari K, Chaouachi A, Souissi N. Diurnal variations in physical performances related to football in young soccer players. Asian J Sports Med 2012; 3 (3): 139
16. Signorile JF, Zink AJ, Szwed SP. A Comparative electromyographical investigation of muscle utilization patterns using various hand positions during the lat pull-down. J Strength Cond Res 2002; 16 (4): 539-546
17. Weir JP, Wagner LL, Housh TJ. The effect of rest interval length on repeated maximal bench presses. J Strength Cond Res 1994; 8 (1): 58-60
18. Hollander DB, Kraemer RR, Kilpatrick MW, Ramadan ZG, Reeves GV, Francois M, et al. Maximal eccentric and concentric strength discrepancies between young men and women for dynamic resistance exercise. J Strength Cond Res 2007; 21 (1): 37-40
19. Seo D-i, Kim E, Fahs CA, Rossow L, Young K, Ferguson SL, et al. Reliability of the one-repetition maximum test based on muscle group and gender. J Sports Sci Med 2012; 11 (2): 221
20. LaChance PF, Hortobagyi T. Influence of cadence on muscular performance during push-up and pull-up exercise. J Strength Cond Res 1994; 8 (2): 76-79
21. Ball T. The predictability of muscular strength and endurance from calisthenics. Res Q Exerc Sport 1993; 64: A39
22. Norton K, Whittingham N, Carter L, Kerr D, Gore C, Marfell-Jones M. Measurement techniques in anthropometry. Anthropometrica 1996; 1: 25-75
23. Faulkner JA. Physiology of swimming and diving. Exerc Physiol 1968: 415-446
24. Matiegka J. The testing of physical efficiency. Am J Phys Anthropol 1921; 4 (3): 223-230
25. Olkin I. Statistical methods for meta-analysis. San Diego, CA: Academic 1985:
26. Hopkins W, Marshall S, Batterham A, Hanin J. Progressive statistics for studies in sports medicine and exercise

science. Med Sci Sports Exerc 2009; 41 (1): 3
27. Hopkins W. Spreadsheets for analysis of controlled trials, with adjustment for a subject characteristic. Sportscience 2006; 10: 46-50
28. Perroni F, Cignitti L, Cortis C, Capranica L. Physical fitness profile of professional Italian firefighters: Differences among age groups. Appl Ergon 2014; 45 (3): 456-461

Table legends

Table I. Relationship among physical and selected anthropometric qualities and pull ups and lat pull performances.

Table II. Comparison between greater pull up performance and lower pull up performance subjects.

Figure legends

Figure 1. Differences (90% confidence intervals) in maximum number of repetitions until failure in pull ups, one repetition maximum in lat pull (1RM Lat Pull), maximum number of repetitions in lat pulls to failure at a load equivalent to body mass (Lat Pull at BM-load), maximum number of repetitions in lat pulls to failure at a load equivalent to 80% of 1RM (Lat Pull at 80% 1RM), value of 1RM in Lat pull divided by body mass (1RM Lat Pull•BM^{-1}), body mass (BM), fat mass (FM), percentage of fat mass (Percent Fat), lean body mass (LBM), percentage of muscle mass (Percent MM) between the higher (HPG, n = 12) and lower pull up performance (LPG, n = 13). Shaded areas represent trivial differences. See methods for the descriptions of the qualitative outcomes.

I. Relationship among physical and selected anthropometric qualities and pull ups and lat pull performances

	Pull ups	1RM Lat Pull	Lat Pull at BM-load	Lat Pull at 80% 1RM	1RM Lat Pull•BM^{-1}	BM	FM	Percent Fat	LBM
M Lat Pull	.09 (-.24 to .42)								
ull at BM-load	.62 (.41 to .83)**	.00 (-.33 to .34)							
Pull at 80% 1RM	-.14 (-.47 to .19)	-.55 (-.78 to -.32)**	-.03 (-.37 to .31)						
Lat Pull•BM^{-1}	.57 (.33 to .79)**	.71 (.54 to .88)**	.53 (.29 to .77)**	-.59 (-.81 to -.37)**					
BM	-.55 (-.78 to -.32)**	.55 (.32 to .78)*	-.61 (-.82 to -.40)**	-.07 (-.40 to .26)	-.20 (-.52 to .12)				
FM	-.52 (-.76 to -.28)**	.36 (.07 to .65)	-.53 (-.77 to -.29)**	.14 (-.19 to .47)	-.20 (-.52 to .12)	.73 (.57 to .89)**			
ercent Fat	-.37 (-.66 to -.08)	.14 (-.19 to .47)	-.36 (-.65 to -.07)	.25 (-.06 to .56)	-.17 (-.50 to .16)	.37 (.08 to .66)	.90 (.84 to .96)**		
LBM	-.50 (-.75 to -.25)*	.55 (.32 to .78)**	-.57 (-.80 to -.34)**	-.12 (-.45 to .21)	-.18 (-.50 to .14)	.98 (.97 to .99)**	.58 (.36 to .80)**	.18 (-.14 to .50)	
ercent MM	.31 (.01 to .61)	-.19 (-.51 to .13)	.33 (.03 to .63)	-.10 (-.43 to .23)	.18 (-.14 to .50)	-.45 (-.72 to -.18)*	-82 (-.93 to -.71)**	-.83 (-.93 to -.73)**	-.30 (-.61 t

e reported as Pearson correlation coefficients, and 90% confidence intervals (in parentheses). * Significant at $P < .05$; **Significant at $P < .01$
: maximum number of repetitions until failure in pull-ups. 1RM Lat Pull: one repetition maximum in lat pull. Lat Pull at BM-load: maximum number of repetitions in lat pulls until failure at a load equivalent to body ll at 80% 1RM: maximum number of repetitions in lat pulls until failure at a load equivalent to 80% of 1RM. 1RM Lat Pull•BM^{-1}: value of 1RM in Lat pull divided by body mass: BM: body mass. FM: fat mass. Perce tage of fat mass. LBM: lean body mass. Percent MM: percentage of muscle mass.

Table II. Comparison between greater pull up performance and lower pull up performance subjects

	LPG	HPG	P-value	Standardized (Cohen) differences (90%CI)	Percent chances for HPG vs. LPG to be lower/similar/greater	
Pull Up (rep)	13.3 ± 2.1	18.5 ± 2.2	.000	2.22 (1.60; 2.84)	100/0/0	Most likely
1RM Lat Pull (kg)	165.0 ± 32.5	165.0 ± 19.1	1.00	0.00 (-0.89; 0.89)	35/30/35	Unclear
Lat Pull at BM-load (rep)	30.9 ± 6.8	43.9 ± 8.3	.000	1.46 (0.87; 2.05)	100/0/0	Most likely
Lat Pull at 80% 1RM (rep)	8.7 ± 2.7	8.2 ± 2.1	.60	-0.23 (-0.96; 0.50)	16/31/53	Unclear
1RM Lat Pull·BM^{-1}	2.1 ± 0.4	2.3 ± 0.1	.05	1.51 (0.25; 2.77)	96/3/2	Very likely
BM (kg)	78.4 ± 8.3	70.9 ± 7.1	.02	-0.99 (-1.69; -0.30)	0/3/97	Very likely
FM (kg)	10.0 ± 2.2	8.2 ± 1.5	.03	-1.14 (-1.96; -0.32)	1/3/97	Very likely
Percent Fat (%)	12.8 ± 2.3	11.5 ± 1.0	.10	-1.11 (-2.23; 0.01)	3/6/91	Likely
LBM (kg)	68.4 ± 7.4	62.6 ± 5.7	.04	-0.94 (-1.67; -0.20)	1/4/95	Very likely
Percent MM (%)	48.3 ± 1.7	48.7 ± 1.4	.46	0.32 (-0.40; 1.03)	61/28/11	Unclear

Data are mean ± SD

High performance group (HPG): Subjects with a pull up performance higher than the average performance of the entire group (n = 12). Low performance group (LPG): Subjects with a pull up performance lower than the average performance of the entire group (n = 13). Pull up: maximum number of repetitions until failure in pull-ups. 1RM Lat Pull: one repetition maximum in lat pull. Lat Pull at BM-load: maximum number of repetitions in lat pulls until failure at a load equivalent to body mass. Lat Pull at 80% 1RM: maximum number of repetitions in lat pulls until failure at a load equivalent to 80% of 1RM. 1RM Lat Pull•BM^{-1}: value of 1RM in Lat pull divided by body mass: BM: body mass. FM: fat mass. Percent Fat: percentage of fat mass. LBM: lean body mass. Percent MM: percentage of muscle mass. CI: confidence interval. All date are presented as differences for HPG compared to the LPG, so that negative and positive differences are in the same direction.

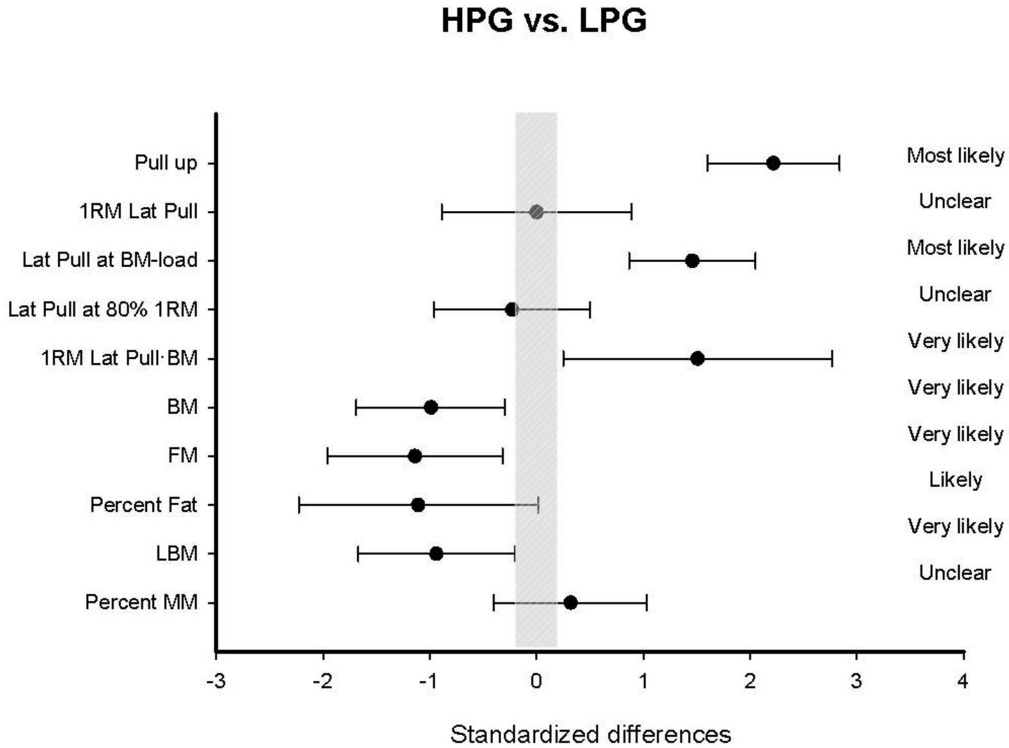

Figure 1. Differences (90% confidence intervals) in maximum number of repetitions until failure in pull-ups, one repetition maximum in lat pull (1RM Lat Pull), maximum number of repetitions in lat pulls to failure at a load equivalent to body mass (Lat Pull at BM-load), maximum number of repetitions in lat pulls to failure at a load equivalent to 80% of 1RM (Lat Pull at 80% 1RM), value of 1RM in Lat pull divided by body mass (1RM Lat Pull•BM^{-1}), body mass (BM), fat mass (FM), percentage of fat mass (Percent Fat), lean body mass (LBM), percentage of muscle mass (Percent MM) between the higher (HPG, n = 12) and lower pull up performance (LPG, n = 13). Shaded areas represent trivial differences. See methods for the descriptions of the qualitative outcomes.