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A Comparison of Body Composition, Upper-Body, and Hand Grip Strength among Royal Thai Army Cadets with Different Pull-Up Performance

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ABSTRACT

Pramkratok W, Prajongjai V, Songsupap T. A Comparison of Body Composition, Upper-Body, and Hand Grip Strength among Royal Thai Army Cadets with Different Pull-Up Performance. **JEPonline** 2024;27(2):19-27. This study compared body composition, upper-body strength, and hand grip strength (HGS) among Royal Thai Army cadets (RTACs) with different levels of pull-up performance (PUP). Twenty-six male RTACs who performed pull-ups either lower than or equal to 12 times (LPG, n = 13) and higher than 12 times (HPG, n = 13) volunteered to participate in this study. In a cross-sectional experimental design, measurements included PUP, body composition, relative one-repetition maximum lat pull (1RM Lat Pull·BW-1), repetitions to failure in lat pull at body weight load (Lat Pull at BW-load), and HGS test. An independent sample *t*-test was used to determine the mean difference between the groups with statistical significance set at P < 0.05. The results indicated that HPG demonstrated significantly greater performance in PUP, dominant HGS, non-dominant HGS, 1RM Lat Pull·BW-1, and Lat Pull at BW-load compared to LPG, while HPG exhibited significantly lower percentage body fat PBF compared to LPG (all, P < 0.001). These findings suggest that training programs focused on reducing fat, strengthening pulling muscles, and improving grip strength may enhance PUP.

Key Words: Military Training, Muscle Strength, Physical Fitness

INTRODUCTION

Physical fitness is a fundamental component of military readiness, influencing the operational effectiveness and performance of soldiers in various military tasks and missions (7,13). Among the critical aspects of physical fitness, upper-body strength plays a pivotal role, particularly in tasks requiring manual dexterity, endurance, and power (1,9,15). The ability to perform pull-ups is often considered a hallmark of upper-body strength and is widely used as a measure of physical fitness in military settings, including the Royal Thai Army cadets (RTACs) testing and training programs (6,12,14). Previous studies have shown that special forces personnel with superior pull-up performance (PUP) tend to perform better in a 5-kilometer weight-carrying test (11) and have a higher probability of passing the Ranger Physical Assessment Test (1). Understanding the factors associated with PUP is thus essential for balancing injury risk and improving physical fitness via optimizing training strategies and enhancing overall military readiness (2,10,17).

Several studies have reported that PUP relies on a complex interplay of factors, including body composition, muscular strength, and grip strength (12,14). Body composition, characterized by the distribution of muscle, bone, and fat mass, can significantly influence an individual's ability to perform pull-ups effectively (5,12,14). Greater muscle mass and lower percent body fat (PBF) are generally associated with improved physical performance and strength-to-weight ratio, which may translate to better PUP (5,12,23). Additionally, upper-body strength, particularly in the muscles responsible for pulling movements such as the latissimus dorsi, biceps, and trapezius, is essential for sustaining repeated pull-up repetitions and is a critical determinant of pull-up proficiency (12).

The Lat Pull test, commonly used to assess upper-body strength, lies in the measurement of performance in exercises targeting similar muscle groups to those engaged in the pull-up exercise (5,14). Previous studies have demonstrated that PUP is correlated with one-repetition maximum lat pull (1RM Lat Pull) (5,12) and maximal lat pull repetitions at a load equivalent to body weight (Lat Pull at BW-load) (12,14). However, our investigation reveals a gap in the literature regarding studies that compare subjects with different levels of PUP. Specifically, only one study compared groups with higher and lower PUP in highly trained individuals (14). It was found that the group with higher PUP had less body weight, fat mass, and muscle mass than the group with lower PUP. Additionally, the group with higher PUP performed significantly better than the group with lower PUP in the Lat Pull at BW load test.

Moreover, hand grip strength (HGS) is another key factor that may influence PUP and overall upper-body strength (12,19,22). While traditionally assessed using dynamometry, HGS reflects the strength and endurance of the muscles in the hands and forearms, which are essential for maintaining grip and stability during pull-up exercises (12,20). Previous research has suggested a positive relationship between HGS with PUP, 1RM Lat Pull, and Lat Pull at BW-load, highlighting the importance of grip strength in supporting upper-body movements and exertion (12). However, there are no studies comparing HGS between subjects who can do higher and lower PUP, especially among military students. Conducting a comparative study between RTACs with higher and lower PUP in this related variable enables us to discern specific patterns and differences in upper-body strength that may contribute to varying levels of PUP.

Therefore, the purpose of this study was to compare body composition, upper-body strength, and grip strength among RTACs with different levels of PUP. We hypothesized that there is a difference in related variables between higher and lower PUP of RTACs. The findings of this study hold implications for the development of tailored training programs aimed at optimizing physical performance and enhancing the overall readiness of RTACs and other athletes.

METHODS

Subjects

Twenty-six men from the Chulachomklao Royal Military Academy volunteered to participate in this study. All participants had completed the same six-month training program, which included standard exercises such as pull-ups and lat pulls. Inclusion criteria were based on the ability to perform pull-ups either lower than or equal to 12 times (LPG, n = 13; age, 22.39 ± 3.18 years; height, 173.23 ± 5.23 cm; weight, 72.74 ± 9.25 kg) and higher than 12 times (HPG, n = 13; age, 21.77 ± 1.64 years; height, 173.77 ± 4.62 cm; weight, 67.43 ± 7.63 kg) with 13 participants in each category (1). Exclusion criteria included the use of drugs or muscle stimulants, any injuries or illnesses that could influence performance, and any musculoskeletal problems affecting the upper extremities. The participant recruitment was facilitated through coordination with the Department of Physical Education via public relations media. Prospective participants from the RTACs accessed the public relations media and contacted the researcher based on the provided information. Prior to participation, the subjects were fully informed about the study's benefits, procedures, and associated risks, and they provided informed consent. The study protocol received approval from the ethics committee at Chulalongkorn University and complied with the guidelines of the Helsinki Declaration.

Procedures

This study used a cross-sectional experimental design to compare body composition, upper-body strength, and grip strength among the RTACs with different levels of PUP (LPG vs. HPG). In the week before the main testing sessions, a familiarization session emphasized proper test execution. The tests occurred in a fitness room under investigators' supervision at a consistent temperature (~24º to 25ºC). To control for time-of-day effects (3), all the tests were conducted between 17:00 and 18:00 hrs. Two testing sessions, 72 hours apart, included body composition and 1RM lat pull tests, followed by the HGS test and the lat pull repetitions to failure using a load equivalent to body weight. The subjects completed a 15-minute warm-up that consisted of jogging, shoulder movements, and 2 submaximal sets of the testing exercise directed by the primary researcher before each test. Throughout the execution of the tests, the subjects were provided with verbal encouragement to ensure that they gave their maximum effort. The subjects were advised to avoid strenuous activities for 24 hours before the measurements, to maintain their regular diet, to abstain from caffeine, and to have a light meal 2 to 3 hours before testing.

Measurements

Pull-Up Test

The subjects executed pull-ups on a standard horizontal bar, following the requirement to lift their body from a fully extended arm hanging position with a pronated grip until their chin cleared the bar. They were instructed to complete the maximum number of free-hanging pull-ups with a maximum 2-second pause between repetitions (14). Any repetitions where the elbow reached a 90º flexion were counted as half repetitions (5). PUP was assessed by quantifying the maximum number of repetitions achieved. Before the pull-up test, all the subjects underwent an identical 15-minute warm-up that involved shoulder movements and 2 submaximal sets of pull-ups. The intraclass correlation coefficient (ICC) for a typical pull-up test has been reported to range between 0.92 and 0.95 (21).

Body Composition

Body composition that comprised height, body weight, and PBF were assessed using a body composition analyzer featuring ultrasonic height measurement (ioi 353, Jawon Medical, Kyungsan City, Korea).

Hand Grip Strength Test

The HGS of both the dominant and the non-dominant hands was assessed using a handgrip dynamometer (Takei Scientific Instruments, model T.K.K. 5401 Grip-D, Japan). To standardize the task, the dynamometer was adjusted so that the base of the handgrip rested on the first metacarpal, and the handle was in contact with the middle aspect of the 4 fingers. The subjects followed the verbal commands ('1, 2, 3, and go!') for each attempt with 2 measurements taken, alternating between hands. They were instructed to exert maximal isometric effort by squeezing the dynamometer for 2 seconds during each measurement. The highest value obtained from the 2 measurements for each hand was divided by the body weight, and the best result was recorded. A rest interval of 1 minute was scheduled between each attempt to prevent muscle fatigue during the test (18).

1RM Lat Pull Test

The 1RM Lat Pull was conducted using a seated lat pull machine (Fex Fitness, model PC 2013, Taiwan) with the seat adjusted for proper arm extension and chin clearance. The subjects used a pronated grip with a consistent handgrip width (approximately 150% of the bi-acromial distance). Before testing, they performed a warm-up consisting of two sets of 5 to 10 repetitions at 60 to 70% of their estimated 1RM. After a 5-minute rest, a mass load was chosen with increments of 2.5 to 5 kg based on performance ease. This process continued until failure, which was achieved in 4 to 6 attempts. The reliability of this method ranged from 0.95 to 0.99 ICC (16), and relative strength to body weight was calculated as 1RM Lat Pull·BW-1.

Repetitions to Failure in Lat Pull using a Load Equivalent to Body Weight Test

The Lat Pull at BW-load was performed using the same device. The subjects followed the same warm-up and test procedures as described for the 1RM lat pull test. Their goal was to complete as many repetitions as possible until reaching task failure with a maximum 2-second pause allowed between repetitions. It was important that the subjects lifted loads within 1 kg of their body weight (14).

Statistical Analyses

All statistical analyses were conducted using SPSS 27.0 (SPSS Inc., Chicago, IL., USA). The data were expressed as means ± SD. Normality of the data was confirmed by the Shapiro-Wilk test. An independent sample *t*-test was used to determine the mean difference between groups (LPG vs. HPG). The Mann Whiney U Test was used to compare the mean difference between groups for a non-parametric statistical analysis. The level of significance was set at an alpha level of $P < 0.05$ for all analyses. Effect sizes (ES) with 95% confidence interval (CI) were calculated using the Cohen's d method and were reported with the following thresholds: trivial (ES < 0.2), small (ES = 0.2 - 0.6), medium (ES = 0.6 - 1.2), and large (ES > 1.2) (8).

RESULTS

Table 1 presents a comparison between the subjects with higher and lower PUP in terms of descriptive statistics that included means ± standard deviations along with the units of measurement and abbreviations used for the tested variables. Interestingly, HPG demonstrated a significantly greater performance in PUP, HGS-D, HGS-ND, 1RM Lat Pull·BW-1, and Lat Pull at BW-load compared to LPG, while HPG exhibited significantly lower PBF compared to LPG (all, P < 0.001).

Table 1. Comparison Between Subjects with Higher and Lower PUP in Terms of Descriptive Statistics.

Variables	Mean ± SD		P-value	95% Confidence Interval of the Difference
	HPG (n = 13)	LPG (n = 13)		
PUP (repetitions)	18.38 ± 2.73	8.58 ± 2.73	< 0.001	7.66; 11.95
PBF (percent)	13.75 ± 3.95	20.82 ± 3.77	< 0.001	-10.20; -3.95
HGS-D (times body weight)	0.70 ± 0.06	0.57 ± 0.07	< 0.001	0.08; 0.18
HGS-ND (times body weight)	0.66 ± 0.07	0.55 ± 0.07	< 0.001	0.05; 0.17
1RM Lat Pull·BW-1 (times body weight)	1.54 ± 0.09	1.23 ± 0.15	< 0.001	0.21; 0.41
Lat Pull at BW-load (repetitions)	19.15 ± 4.58	10.77 ± 4.10	< 0.001	4.86; 11.91

Table 2 presents the ES with 95% CI between HPG and LPG. Pairwise comparisons between HPG and LPG on all relevant variables are large. HPG exhibited a larger increase in PUP, HGS-D, HGS-ND, 1RM Lat Pull·BW-1, and Lat Pull at BW-load (ES = [1.58 - 3.70]) compared to LPG, while the differences in PBF indicated a larger decrease (ES = -1.83).

Table 2. Displaying Effect Sizes with 95% Confidence Interval Between HPG and LPG.

Variables	Effect Sizes with 95% CI	Interpretation
PUP (repetitions)	3.70, 95% CI [2.36; 4.98]	large
PBF (percent)	-1.83, 95% CI [-2.75; -0.89]	large
HGS-D (times body weight)	1.98, 95% CI [1.02; 2.92]	large
HGS-ND (times body weight)	1.58, 95% CI [0.68; 2.45]	large
1RM Lat Pull·BW-1 (times body weight)	2.53, 95% CI [1.47; 3.56]	large
Lat Pull at BW-load (repetitions)	1.93, 95% CI [0.97; 2.86]	large

DISCUSSION

The purpose of this study was to compare body composition, upper-body strength, and grip strength among RTACs with different levels of PUP. We hypothesized that RTACs with higher PUP would exhibit distinct body composition, upper-body strength, and grip strength compared to RTACs with lower PUP. Our findings strongly support this hypothesis.

Regarding body composition, HPG demonstrated significantly lower PBF compared to LPG. This aligns with previous research suggesting a negative association between PBF and PUP (12). Additionally, this finding underscores the importance of maintaining optimal body composition characterized by higher muscle mass and lower fat mass to enhance physical performance and strength-to-weight ratio, thus facilitating better PUP (4,5,23,24). However, our finding contrasts with the results of a previous study (14) that found no relationship between PUP and PBF and no significant difference in PBF between HPG and LPG. This discrepancy may be explained by the different levels of PUP and fat percentage among the low-performance group, in which the subjects in that study had higher PUP and lower fat percentages than our study. Our result suggests that implementing training programs that promote development of lean muscle mass while reducing body fat can be beneficial. This could involve a combination of resistance training and dietary modifications.

In terms of upper body strength, the present study demonstrated that HPG outperformed LPG in all upper-body strength measurements, including 1RM Lat Pull·BW-1 and Lat Pull at BW-load. This indicates a stronger capacity for pulling movements, which is a critical component of

PUP. These findings are consistent with those of several previous studies (12,14) that demonstrated significant positive relationships between PUP and 1RM Lat Pull·BW-1, and Lat Pull at BW-load. Additionally, a previous study also reported a significant difference in 1RM Lat Pull·BW-1, and Lat Pull at BW-load between HPG and LPG (14). This finding recommends that specific exercises targeting the latissimus dorsi, biceps brachii, and trapezius muscles, along with variations of pull-ups, should be incorporated into training routines to improve PUP.

Furthermore, to our knowledge, this is the first study to compare the grip strength between HPG and LPG. The results support our hypothesis, revealing that both HGS-D and HGS-ND were significantly higher in HPG compared to LPG. This finding aligns with prior studies emphasizing the importance of grip strength in supporting upper-body movements and exertion during pull-up exercises (12,20). Our findings indicate that individuals with low HGS may have trouble exerting sufficient pulling force during pull-ups, leading to quicker fatigue and potentially impaired performance. This implies that individuals with higher HGS generally excel in the pull-up test since the exercise necessitates a robust grip to sustain body weight throughout the movement. Hence, the results suggest that exercises that target the forearm and hand muscles, such as handgrip dynamometer training or dead hangs, can improve grip strength and support pull-up proficiency.

Limitations in this Study

It is important to point out that the small sample size and homogeneous population of RTACs may have limited the generalizability of our findings to other military populations. Future research that incorporates larger and more diverse samples is needed to validate and extend the findings.

CONCLUSIONS

Our findings indicate that RTACs with higher PUP have distinct body composition, upper-body strength, and grip strength compared to those with lower PUP. Specifically, those with higher PUP had lower PBF that highlights the importance of maintaining optimal body composition for improved physical performance. Additionally, RTACs with higher PUP demonstrated superior upper-body strength and grip strength that emphasizes the significance of specific exercises targeting relevant muscle groups. These findings suggest that training programs focused on reducing fat, strengthening pulling muscles, and improving grip strength may enhance PUP. Overall, the research provides valuable insights into the factors that contribute to pull-up proficiency among military personnel, which indicate the intricate interplay between physical attributes and performance outcomes.

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