Title

The Association Between Grip Strength and Isometric Mid-Thigh Pull Performance in Elite Footballers

Titre

Association entre force de préhension et tirage isométrique mi-cuisse pour des footballeurs de haut niveau.

Brief Running Head

Grip Strength Isometric Mid-Thigh Pull Elite Footballers

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Abstract

Objectives: The purpose of the present study was to analyse the association between grip strength and performance of the standardised protocol of the isometric mid-thigh pull (IMTP) test.

Methods: 31 elite premier league footballers completed test-retest measures of peak force (PF) grip strength and IMTP, measures were taken 7 days apart. Post completion of the test-retest 3 maximal IMTP and bilateral grip strength measures were taken. Mean PF was calculated bilaterally for each assessment. Linear relationships were determined for test-retest and Grip Strength Test (GST) and IMTP PF output.

Results: Test-retest of the GST and IMTP displayed significant almost perfect correlations bilaterally ($p \leq 0.001$, $r = 0.92 – 0.94$, CI = 0.85 – 0.96). Bilateral moderate-large significant correlations were also identified between grip strength and IMTP PF ($p \leq 0.05$, $r = 0.54 – 0.72$, CI = 0.30 - 0.86).

Conclusions: GST and IMTP are reliable and repeatable measures. Findings in the present study indicate consideration must be given to the influence of grip strength on maximal IMTP PF output. Previous literature describes standardisation procedures for IMTP performance. Pre-completion of IMTP measures in elite footballers, performance practitioners should consider assessment of the athlete's grip strength despite the use of lifting straps.

Key words: soccer, conditioning, injury risk, screening, assessment

Abstrait

Objectifs : Le but de cette étude était d'analyser l'association entre la force de préhension (ou force de grippe) et les performances sur un test standardisé de tirage isométrique mi-cuisse (TIMC).

Méthodes : 31 joueurs de football haut niveau de Premier League prirent part à un test-retest mesurant la force maximum (FM) de grippe et de tirage isométrique à mi-cuisse, enregistrés à 7 jours d'intervalle. À la suite du test-retest, 3 mesures maximales de TIMC et de force de grippe bilatérale furent retenues. La moyenne de FM bilatérale fut calculée pour chaque évaluation. La relation linéaire fut déterminée entre le test-retest ; et entre la force de grippe et le tirage isométrique mi-cuisse.

Résultats : Les test-retest de force de grippe et de TIMC bilatérale ont montré, respectivement une corrélation significative presque parfaite ($p \leq 0.001$, $r = 0.92 – 0.94$, CI = 0.85 – 0.96). La FM de grippe et le TIMC bilatérale ont aussi montré une corrélation significative modérée à large ($p \leq 0.05$, $r = 0.54 – 0.72$, CI = 0.30 - 0.86).

Conclusions : La force de grippe et le TIMC sont des mesures fiables et reproduisibles. Les résultats de l'étude ici présente, indiquent que l'influence de la force de grippe sur les performances maximales de TIMC doit être considérée. La standardisation des procédures de TIMC est précédemment décrite dans la littérature. Préalable a des mesures de TIMC pour des footballeurs élites, préparateurs physiques devraient considérer l'évaluation de la force de préhension des athlètes, quand bien même ils utiliseraient des sangles.

Mots clés : football, conditionnement physique, risque de blessure, évaluation.

INTRODUCTION

Injury risk factors in football are quantifiable via a battery of tests, with maximal strength commonly reported and performed by practitioners to determine a player's readiness to train or return to functional activity post injury[1,2]. Quantifying strength output within elite athletic populations provides contemporary debate amongst practitioners with regards to the type of test, timing of test within a training week and metrics utilised. Literature has highlighted several forms of strength measures, which include repetition max (RM), eccentric, concentric and isometric, to name a few[3,4,5]. The diverse nature of the equipment utilised to determine strength output also poses a predicament for sports performance practitioners, with decisions drawn on the sensitivity of the test and reliability of measures taken[6]. Debate surrounding the type of strength testing selected in an elite performance environment should consider the following factors: relationship to mechanisms of common injuries, transferability of the information to performance and potential detrimental effects of the test on the athlete[7].

Concentric tests have been criticised in literature for not replicating muscular demand during functional performance and have limited association with the mechanisms of injury associated with common injuries in football, i.e. hamstrings[8,9]. Utilisation of RM testing has been documented as transferable to performance and literature has demonstrated its reliability[10]. The fatiguing nature of determining an individual's RM however is a concern for practitioners and utilised within a normal training week could potentially increase injury risk[1]. Quantifying elite athlete's eccentric strength profile is a common approach utilised within football[8]. This is due to its association with injury risk and functional performance[9]. Literature has continuously highlighted the damaging nature of eccentric muscle contractions[11,12], providing sports performance practitioners with the dilemma of how to incorporate this muscle assessment when players are in competition, particularly within fixture congested periods[13].

A contemporary alternative to quantify lower limb strength parameters in athletes is the isometric mid-thigh pull (IMTP)[14,15]. Isometric strength testing is highly reliable, has low measurement error and variability[4,6] and is less provocative than eccentric testing, thus reducing the risk of injury[6,14,15]. In addition, IMTP testing has displayed strong correlations between short explosive sprints, representing an acceleration in football to press play and speed of change of direction[16]. Suggesting measures of

IMTP link closely with performance output. However, debate exists as to whether these performance relationships exist between absolute or relative peak force (PF) measures[17,18]. Literature also highlights strong associations with dynamic strength exercises, indicating that the IMTP performance is a clear indicator of strength output[19]. Early research identified issues surrounding standardisation of the testing protocols within papers, but this was addressed by Comfort et al., (2019)[1]. Key considerations highlighted in the paper emphasised consideration of bar height, body position, grip width, foot position and consistency of these measures within each lift the athlete completes.

Literature has discussed the use of lifting straps/athletic tape to reduce the effect of grip strength as a limiting factor[20,21]. Although, it is noted that actual effect of grip strength when utilising the current standardised protocol suggested by Comfort et al., (2019)[1], has not been analysed. Successful completion of the IMTP requires the athlete to grip the bar and push as hard as possible with the legs to generate force[1]. Theoretically, requiring significant grip strength to be able to perform the IMTP effectively and produce maximal force. Reliance on lifting straps to successfully perform the lift would potentially place excessive load through the wrist joint, causing discomfort to the athlete and thus the potential to reduce force application. Examination of the relationship between grip strength and IMTP performance is limited within current literature. Although handgrip strength may not be directly associated with usual characteristic assessment in footballers per se, determining whether grip strength is a factor in IMTP performance may have implications on the output generated by the athlete when performing a maximal IMTP test. Therefore, the aim of the present study is to determine the relationship between the hand grip strength and IMTP in elite players within a premier league football club.

METHODS

Subjects

Thirty-one elite U23 category 1-status academy male footballers from an English Premier League Football Club completed the present study, age 20.98±2.49 years; height 183.40±8.93 cm and weight 77.65±8.38 kg. All players eligible for the study were in full training, free from injury and available for competitive selection. Normal screening protocols completed at the club include completion of the IMTP test, therefore each player has been exposed to the protocols completed in the present study. Players were advised to refrain from caffeine or additional supplement intake up to 24 hours prior to data collection. This bout of testing was completed in a normal training week, mid-competitive season when the players had returned post a recovery day. All participants provided written informed consent in accordance with the department and host university faculty research ethics committees, and in accordance with the Helsinki Declaration (2018).

Design

This was an experimental study designed to investigate the reliability of grip strength test (GST) and standardised IMTP test in elite footballers. Further to this, the study analysed the linear relationships between maximal grip strength on the IMTP peak force (PF) output of elite male footballers. All subjects completed all testing within the study. Prior to any testing anthropometric data of each of the athletes was taken and familiarisation trials of both the GST and standardised IMTP test were completed. Week 1 subjects were asked to complete 3 maximal seated, elbow extended grip strength measures utilising a hand-held dynamometer, followed by 3 maximal IMTP. This process was repeated on week 2. Mean scores from each of the 3 lifts were then taken for analysis from each week. Each of the familiarisation and testing sessions were separated by 7 days. Week 3 consisted of each athlete completing 3 maximal grip strength measures and 3 maximal IMTP measures. Again, mean scores of the 3 measures were taken for analysis and linear correlations were calculated for PF measures.

Methodology

Participants completed a familiarisation trial 7 days prior to testing to negate potential learning effects[22]. This included completion of 3 maximal repetitions of the hand grip dynamometer (left and right) and IMTP. Prior to any testing all participants completed the standardised dynamic warm up protocol proposed by Comfort et al., (2019)[1], which consisted of 3 second repetitions of IMTP performance at 50%, 75% and 90% maximal efforts, each completed 60 seconds apart. All testing was completed between 13:00 and 17:00 hrs to account for the effect of circadian rhythm and in accordance with regular competition times[23]. Post familiarisation trials all participants completed a test-retest to determine the reliability of measures on both the hand grip dynamometer and IMTP. Measures on both pieces of equipment were completed on two separate occasions, with 7 days between test and retest to consider learning and fatigue effects[22]. On completion of the test-retest data collection, participants were again given a further 7 days before completion of 3 maximal IMTP lifts and 3 maximal grip strength tests to determine correlation.

All hand grip testing was completed with the same hand grip dynamometer (Jamar ® Hydraulic Hand Dynamometer (Model J00105) (Sammons Preston, Bolingbrook, Illinois)) adhering to ASHT (American Society of Hand Therapists) clinical assessment guidelines[24]. The dynamometer was set at the second handle position for each participant. Each player sat in a straight-backed chair, with back supported and feet flat on the floor. The shoulder was adducted and neutrally rotated and forearm/wrist in neutral position. The elbow was extended to replicate the position it would be in when completing the IMTP, this position has previously shown excellent reliability[25]. The dominant and non-dominant side were both subjected to 3 measures of maximal grip strength on the dynamometer, with the average of the 3 combined scores utilised for analysis.

Completion of all IMTP testing followed the standardisation protocol[1]. Measurements of PF were obtained by completing the IMTP via a force platform (ForceDecks FD4000 (ValdPerformance, Australia, 2018). Prior to completion of the IMTP correct body position for each participant was determined and repeated for each test completed. Bar height was set to replicate the 2nd pull position during the clean, adjusting to ensure that optimal knee (125-145°) and hip (140-150°) angles were set, due to body position being shown to significantly affect force generation[4,14,15, 26]. Angles were quantified utilising a hand-held goniometer. The goniometer was placed on the lateral femoral condyle, with upper arm following the line of the femur and lower arm tracing the line of the fibula to quantify knee angle. Hip angle was determined by placing the goniometer on the greater trochanter, with the upper arm tracing the torso and lower arm the line of the femur.

Once angles of the two joints were determined, observation of the position of the athlete was made, ensuring an upright torso with slight flexion of the knee and dorsiflexion of the ankle. Shoulder girdle was retracted and depressed, with the shoulders above or slightly behind the vertical plane of the bar. Feet were hip width apart and centred beneath the bar, with the thighs in contact with the bar. Positioning of the athlete and a final assessment was completed to ensure they were in the correct position and no tension was applied to the bar due to its negative effect on joint angle[4]. A record of each participant's body position ensured consistency of testing within each repeated lift. During each lift completed athletes were secured to the bar with lifting straps placed around the wrists[20,21].

On the completion of each lift the athlete was provided with standardised instructions provided by the club's strength and conditioning coach. These included pushing the feet as hard as possible in to the ground; drive the feet in to the force platform not pulling the bar with the arms or rising on the toes; apply pretension to ensure correct body position and allow a pre-test force baseline (achieved by observing the force trace to ensure it was consistent with body mass); provide a countdown of 3-2-1 Pull to initiate the IMTP to maximum. During the test the athlete was provided with verbal encouragement[27], completing 3 successful maximal trials without any errors. Ensuring each trail was within 250N of one another[20,21].

Statistical Analysis

All participants completed 3 assessments on the hand GST and IMTP. Each assessment consisted of 3 repetitions within each test, with maximal grip strength and IMTP PF being ascertained. Mean force for both GST and IMTP for both the left and right sides were taken for data analysis. Force data for both GST and IMTP were displayed as Newtons (N) and Peak Force (PF). These values were identified for each participant and utilised for analysis.

Pearson's correlation coefficients were calculated to quantify the linear relationship between test-retest for both IMTP and GST. This was also completed to determine the linear relationship between GST and IMTP force outputs. All statistical analysis was completed using PASW Statistics Editor 25.0 for windows (SPSS Inc, Chicago, USA). Statistical significance was set at $P \leq 0.05$. Coefficient of correlation (r) and respective level of significance (p value) describes total variance. The following criteria quantified magnitude of the correlation <0.1, trivial; >0.1 to 0.3, small; >0.3 to 0.5, moderate; >0.5 to 0.7, large; >0.7 to 0.9, very large; and >0.9 to 1.0, almost perfect.

RESULTS

Table 1 summarises the mean and standard deviation scores achieved for all metrics observed within the present study.

******Insert table 1 here******

Test-retest of the GST displayed significant correlations for both the left ($p \leq 0.001$, r = 0.92, CI = 0.88 – 0.96) and right hand ($p \leq 0.001$, r = 0.93, CI = 0.89 – 0.97). Displaying almost perfect correlations between each test, indicating excellent test-retest reliability. The same was also noted for the IMTP test-retest when utilising Comfort et al., (2019) standardisation protocol. Bilaterally IMTP PF displayed significant correlations, left ($p \leq 0.001$, r = 0.92, CI = 0.85 – 0.97) and right ($p \leq 0.001$, r = 0.94, CI = 0.91 – 0.96).

****** Insert Table 2 Here ******

****** Insert Table 3 Here ******

Significant correlations displayed between GST, tested with the handheld dynamometer, and PF ascertained via IMTP performance on the ForceDecks (Grip (L) and IMTP (L): $p \leq 0.05$, r = 0.72, CI = 0.55 – 0.86 and Grip (R) and IMTP (R): p = 0.01, r = 0.54, CI = 0.30 – 0.77). Contralateral relationships between grip strength and PF also displayed no significant correlation between Grip (L) and IMTP (R): $p > 0.05$, r = 0.22, CI = -0.19 – 0.62, but significant between Grip (R) and IMTP (L): $p \leq 0.05$, r = 0.35, CI = 0.12 – 0.60). Significant correlations were also displayed between GST (L) and (R) ($p \leq 0.001$, r = 0.68, CI = 0.46 – 0.83). No significant correlations were displayed between IMTP (L) and IMTP (R), ($p > 0.05$, r = -0.02, CI = -0.36 – 0.36).

****** Insert Table 4 Here ******

******Insert Figure 1 Here******

DISCUSSION

The aim of the present study was to ascertain the reliability of repeated measures of GST and IMTP within an elite football population and to investigate the relationship between grip strength and IMTP performance. PF measures within both tests were ascertained and utilised for comparison. The test-retests performed on both the GST and IMTP testing highlighted almost perfect correlations, suggesting both testing procedures were extremely reliable in this athletic population. These findings were consistent with previous literature[4,6]. Isometric contractions have been shown to be less damaging than other methods of muscle assessment[6,14,15]. Thus, making them an attractive method of assessing a player's readiness to train or injury risk, particularly in periods of competition or fixture congestion[13]. PF measures ascertained from the IMTP test have been associated with measures of functional performance[16]. Although, it is strongly debated that these PF measures are required to be relative to the subject's weight[17,18]. Absolute PF measures were taken within the present study, as the objective was to ascertain whether grip strength still influenced force output when completing the IMTP despite the use of the standardised protocol proposed by Comfort et al., (2019)[1]. Sports performance practitioners should carefully consider the metrics observed when completing the IMTP test when quantifying the athlete's readiness to train, progression in rehabilitation or identification of injury risk.

Main findings from the present study highlight significant moderate to large correlations between players grip strength in relation to PF and their IMTP performance (0.54 - 0.72). It is suggested that securing of the participants to the bar with lifting straps, may reduce the effect of grip strength on IMTP performance, but it does not eliminate its effect, as suggested in earlier literature[20,21]. Importantly, findings from this current body of work indicate that grip effect can still not be discounted despite utilisation of a standardised protocol[1]. Poor grip strength when performing IMTP maximally may have implications of loading through the wrist particularly when attached to the bar with lifting straps. The straps and load applied when performing the test may cause a distraction of the wrist, resulting in discomfort to the athlete and thus reducing the amount of force applied. The effects of this could be catastrophic in youth athletes with an immature skeleton[28]. It must also be considered that athletes may place less emphasis on gripping the bar due to the attachment of lifting straps. Either scenario could potentially result in reduced/poor performance or injury risk.

Practitioners must be prudent to advise that despite the use of lifting straps athletes must apply maximal grip to the bar when performing. This approach should be considered in any standardisation protocol associated with the IMTP. Previous literature[20,21] cited by Comfort et al., (2019)[1] identified the use of lifting straps, taping or a combination of both. Both papers described that the utilisation of these methods ensured that grip strength was not a limiting factor in the IMTP protocol. It is important to note that although these papers identified interclass correlation coefficients (ICC) scores for the described methods completed, they did not identify grip strength performance of the athletes. Comparisons were made between varying metrics associated with IMTP and a dynamic lift. Therefore, not allowing the assumption that grip strength was no longer a limiting factor. The present study directly identifies relationships between grip strength and IMTP performance. Further research in this area should consider ICC values of athletes performing IMTP with and without wrist support, but also compare outputs in relation to wrist support method utilised in the lift.

Recent studies indicate several positive reasons for utilising the IMTP test as a method of quantification to inform injury risk, readiness to train or play or a progression marker in rehabilitation[29,30]. The findings of the present study clearly support these earlier conclusions. Emphasis is placed on legs pushing through the floor during performance of the IMTP to exert maximum output. Although the present study analyses the effect of grip strength it is important to appreciate that performance of the IMTP requires stabilisation of the hips, as well as maintaining a good posture representative of the second pull position. Any failure to maintain this throughout performance of the IMTP may result in inaccurate outputs being produced. If the grip strength of the athlete is not adequate the athlete may create pull from other areas of the body, meaning an adjustment of the position described in the methods of the current and previous papers[1,4]. It is important to emphasise to the athlete or practitioners the effect inadequate grip application may have on performance. Thus, highlighting that pre performance of this test practitioners may consider performance of a GST.

Limitations:

The present study identifies relationships between grip strength and IMTP performance. Limitations exist within the present body of work, most notably failure to consider other metrics exhibited during the IMTP test. Future work in this area could consider other performance metrics exhibited in the IMTP test like rate of force development (RFD), another metric like PF that has been strongly associated within literature with functional performance[1]. Positioning of the athletes during testing was standardised in relation to protocols described in previous work, but the effect of poor positioning was not quantified[1]. Further research should consider the effect poor grip strength may have on the athletes positioning when performing the IMTP test. Consideration must also be given to other limiting factors associated with the performance of the IMTP, which may include reduced dorsiflexion of the ankle or poor shoulder and shoulder girdle function. Sports performance practitioners need to consider the importance of these factors and appropriately screen the athlete to ensure optimal performance can be achieved when completing the IMTP test.

PRACTICAL APPLICATIONS

- Consideration must be given to the effect of grip strength on IMTP performance when utilised as a test to quantify maximum PF in elite footballers.
- Although grip strength has implications on maximum PF output, the IMTP test still represents a reliable and repeatable test for quantifying PF output in elite footballers.
- Careful consideration should be given to assessing the grip strength of the athlete pre completion of the standardised protocol for IMTP test.

APLICATIONS PRATIQUES

- L'effet de la force de grippe sur les performances de TIMC doit être considéré dans un test de force maximal pour des joueurs élites de football.
- Bien que la force de grippe soit impliquée dans la force maximal produite, le TIMC reste un test fiable et reproduisible pour la quantifier la force maximale de joueurs élites de football.
- L'évaluation de la force de grippe des athlètes préalablement a un test standardise de TIMC devrait être considérée avec attention.

CONCLUSIONS

The findings of the present study suggest that grip strength has an influence on IMTP test performance. The importance of a standardised protocol has previously been identified and should continually be utilised within IMTP testing within elite sports performance environments. Although it is important for practitioners to consider the assessment of an athlete's grip strength pre a maximum PF test. Further research should consider the utilisation of quantifying maximum PF output with the IMTP. Thought should be given to analysing grip strength and other quantifiable measures of lower limb PF.

CONCLUSIONS

Les résultats de l'étude ici présente suggèrent que la force de grippe a une influence sur les performances de test de TIMC. L'importance d'un protocole standardise a déjà été identifié précédemment, et devrait continuer à être utiliser pour le test TIMC dans le contexte de la performance sportive de haut niveau. Il est toutefois important pour les préparateurs physiques de considérer l'évaluation de la force de grippe des athlètes avant un test maximal de TIMC. Davantage d'études devraient considérer l'utilisation de quantifier les mesures maximales de force de TIMC. Une attention particulière devrait être donnée à l'analyse de la force de grippe et autres mesures quantifiables de la force maximale des membres inférieurs.

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