

## RESEARCH ARTICLE

## Ballistic, maximal strength and strength-endurance performance of male handball players: Are they affected by the evaluator's sex?

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## Abstract

This study aimed to elucidate whether ballistic, maximal strength and strength-endurance performances are affected by the sex of the evaluator. Sixteen young male handball players attended two testing sessions that only differed in the sex of the evaluators (2 women vs. 2 men). The two sessions were performed in a counterbalanced order. Ballistic performance (countermovement jump height and throwing velocity), maximal strength performance (squat and bench press [BP] one-repetition maximum [1RM]), and strength-endurance performance (number of repetitions-to-failure in BP and average velocity of the set in the squat) were assessed in both sessions. BP 1RM was greater in the presence of women evaluators ( $p = 0.036$ ,  $ES = 0.09$ ), whereas no differences were observed for the remaining variables ( $p \geq 0.254$ ,  $ES \leq 0.19$ ). Low correlations ( $r$  median [range] =  $-0.074$  [ $-0.693$ ,  $0.326$ ]) were observed between the different performance tests for the percent differences between both testing sessions. The sex of the evaluators has minimal influence on a number of physical traits in young male handball players when they are tested in the presence of other members of the team, while the low correlations indicate that a higher performance in one test under the presence of women does not imply a higher performance under the presence of women in other performance tests.

## Introduction

Successful performance in many sports depends on the athlete's ability to jump, throw, kick, and run at very fast velocities for a prolonged period of time [1]. Previous studies have evidenced a strong link between the outcomes of upper- and lower- body tests and athletic

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**Abbreviations:** 1RM, one-repetition maximum; BP, bench press; CMJ, countermovement jump; ES, Cohen's *d* effect size; *r*, Pearson's correlation coefficients.

performance [2–6]. For example, ballistic performance (e.g., jump height or throwing velocity) has been shown to be able to discriminate between athletes of different competitive levels [7, 8]. Similarly, maximal strength test outcomes, commonly assessed as the one-repetition maximum (1RM), are positively associated with sprint performance [6] and with the ranking of wrestlers [4] and judokas [5]. Besides the importance of ballistic performance and maximal strength, the ability to repeatedly develop a high level of force without decreasing performance (i.e., strength-endurance) is of paramount importance in many sports [9, 10]. For example, handball players need to perform high-intensity actions (e.g., jumps, throws, and changes of direction) with maximal performance from the beginning to the end of the match. Therefore, it is not surprising that these important and distinctive qualities (ballistic, maximal strength and strength-endurance) are frequently assessed as a part of test batteries to detect athletes' strengths and weaknesses in order to prescribe individualized training programs [10].

It is well documented that sports performance does not only depend on physiological, motor, technical, and tactical abilities, but also on social influences as it has been documented by Triplitt [11] who argued that the presence of others increases arousal of the “competitive instinct” and serves to increase physical competence. This phenomenon, named “social facilitation”, indicates that people perform simple tasks with a greater performance in presence of others in comparison to when they are alone [12], which has been confirmed by a number of studies. For example, Baker et al. [13] and Rhea et al. [14] demonstrated that athletes lifted more weight during a 1RM test when observers (i.e., passive spectators) were present, while Murray et al. [15] found a greater rowing performance (higher distance and power output in a 9 min self-paced rowing test conducted on an ergometer) in the presence of others even in a virtual reality environment. Furthermore, it has been noted that the performance of athletes is greater when the sport activity is performed in a group that is performing the same activity [16], in the presence of sports adversaries [14] or in the presence of spotters (i.e., a person who watches and helps someone who is performing some exercise in order to prevent potential injuries) [17]. However, one factor that has been frequently overlooked is the sex of the observer.

Although the presence of an observer of the opposite sex could affect the outcomes of physical tests, a low number of studies have analyzed this topic [18–20]. Nevertheless, those studies are generally in consent that the presence of female observers when males are evaluated produces an increase in strength performance [13] and a decrease in the ratings of perceived exertion [21]. However, when females took the role of spotters the improvements in the BP 1RM did not reach statistical significance compared to the use of male spotters [20]. Although it has been highlighted as a significant factor in other research areas (i.e., psychology, sociology, etc.) [22], there is paucity of studies exploring whether the sex of the evaluator influences athletic performance. To our knowledge, there are only two studies on this topic and both of them suggested that grip strength [23] and 50 yards dash, shuttle run test or sit ups [24] of undergraduate students were unaffected by the sex of the evaluators. However, an important aspect of these studies is that the group of subjects tested was composed by both men and women. Also, it has not been elucidated whether a possible effect of the sex of the evaluator could differ among different physical tests. Therefore, it is of interest to explore whether the evaluator's sex influences physical performance of male subjects and whether the potential effect of the evaluator's sex affects differently ballistic, maximal strength and strength-endurance performances.

To fulfil these research gaps, we designed a study with the aim to explore whether the sex of the evaluator influences ballistic (countermovement jump [CMJ] height and throwing velocity), maximal dynamic strength (squat and bench press [BP] 1RM) and strength-endurance (squat and BP sets performed against the 85% of 1RM) performance of young male handball