TECHNICAL NOTE

Increasing Compliance to Instructions in the Squat Jump

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Abstract

The purposes of this investigation were to evaluate the occurrence of a small amplitude counter-movement (SACM) in SJ (squat jump) trials of elite athletes to determine the efficacy of gross observation and the use of a portable position transducer to determine whether or not a SACM occurred. The subjects ($N = 30$, 20.1 ± 3.0 years, 199.0 ± 8.4 cm, and 87.2 ± 9.5 kg) were a combination of high-performance (National Team) and elite athletes (Olympian) from the sports of athletics, swimming, and volleyball. All subjects performed SJ trials on a force platform, with a linear position transducer attached to a bar placed across the shoulders. Subjects performed the SJ from a depth that allowed for a 90° knee angle, with the subject's instructed to maintain a 3-second isometric hold preceding the concentric action of the jump. One hundred twenty-five SJ trials were observed for a SACM and analyzed (using the force plate data and position transducer data) for a SACM. Of the 125 SJ trials, 69 trials (55.2%) were observed to have a SACM by the researchers. In the remaining 56 trials, 43 of these trials contained a force unload (≥10% body mass) before initiation of the concentric action, indicating a SACM. Of the 119 SJ trials where a force unload was observed and detected by the force-time graph, 118 (99.2%) of these trials also showed a change in displacement using the displacement-time graph from the linear position transducer. The results of this study indicate that achieving compliance to protocol in the SJ is difficult, and that gross observation is inadequate in detecting a SACM in the SJ. From a practical perspective, these results suggest that using a force plate or a linear position transducer would allow the strength and conditioning coach to ensure compliance to instructions in the SJ.

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Introduction

Displacement measurements achieved in various vertical jumping tasks have been considered to be an integral component of an overall testing battery for many sports because they are considered a valid measure of leg extensor power (6); this is also the case for sports in which jumping is not integral to the sport or event (1). This practice is based on practical experience, and research evidence that demonstrates strong relationships between vertical jump measures and performance measures in sports that require powerful leg extension (1,6).

Squat jumps (SJ) are a common test of concentric-only leg extensor power (1,4–6). It is believed that by preceding the concentric jump action by a brief isometric hold lasting about 3 seconds, the athlete is unable to use the contribution from a stretch-shortening cycle (SSC) because the SSC is dependent on the rate of pre-stretch and a minimal duration between the prestretch and the concentric action, known as the amortization phase (2). Therefore, the SJ is considered a valuable test in evaluating athletes who require powerful leg extension where a significant isometric hold precedes the concentric action, for instance, swim and athletics starts, and to compare "concentric-only" power with leg extensor power using a counter-movement vertical jump (CMVJ), which allows utilization of a SSC (4,5).

When testing the SJ, researchers have observed that it often requires considerable familiarization of subjects to reduce or eliminate small eccentric actions (~1–2 cm change in C of G), which have been termed small amplitude counter-movements (SACM), before the initiation of the concentric jump (6). Ideally, the presence of a SACM is determined by examining the force trace of the movement to identify an unloading of the force immediately prior to the concentric action. This unloading occurs when an athlete lowers their centre of gravity (C of G) just prior to initiation of the propulsive phase; the force trace will show a decline from the steady state held prior to this movement (Figure 1).

By strict definition, any SJ where a SACM is present should be discarded from consideration. Although Hasson et al. (3) observed that a SACM equivalent to a 1- to 3-cm change in C of G does not significantly alter SJ test results, recent observations at the Australian Institute of Sport (AIS) indicate that

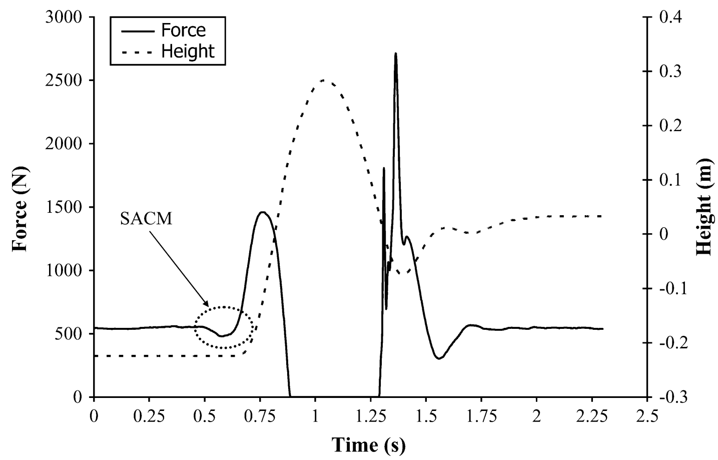

Figure 1. Sample force trace of squat jump. Note the SACM, circled, just before the concentric phase of the jump. Note there is no observable SACM on the height trace in this example. This SACM represents a force unload of >10% of body weight.

for subjects within our elite athlete population, this finding does not apply (Table 1). Considering that in the field-test setting (using jump ergometers and jump and reach methods), there is no instrumented means from which to gauge a SACM, it is common practice to include SJ trials provided no 'observable' counter movement occurs. However, whether or not gross observation is adequate in detecting a SACM is unknown. Furthermore, it is unrealistic to use a portable force-plate in many field-testing settings. Therefore the purposes of this investigation were to evaluate the occurrence of SACM's in SJ trials of elite athletes in order to determine the efficacy of gross observation in determining whether or not a SACM occurred, and to evaluate the use of a portable position transducer to determine whether or not a SACM occurred.

Methods

Experimental Approach to the Problem

An analysis of 125 SJ trials was performed. The researchers recorded and logged each grossly observed SACM, and instrumented analysis was performed on each of the 125 trials using both a force-plate and position transducer. This analysis allowed the researchers to evaluate the efficacy of gross observation in determining whether or not a SACM occurred, as well as the ability of a portable position transducer to detect a SACM.

Subjects

Thirty subjects whose mean ± SD age (years), height (cm), and mass (kg) were 20.1 ± 3.0, 199.0 ± 8.4, and 87.2 ± 9.5 respectively, participated in this study. The subjects included

Table 1. Mean SJ height achieved by 5 elite athletes from trials with and without a SACM present (2 jumps for each condition, for each athlete).

Athlete descriptor	SACM present (m)	No SACM (m)	Difference (m)
Elite volleyball	0.512	0.489	0.023
Elite sprinter swimmer	0.486	0.417	0.069
High-performance athletics sprinter	0.475	0.440	0.035
Elite athletics sprinter	0.509	0.423	0.086
High-performance athletics sprinter	0.396	0.379	0.017
Mean	0.477	0.430	0.046

Note that although a *t*-test reveals nonsignificant differences with *P* values of 0.05, Cohen's effect size statistic is 1.05, indicating a large magnitude of difference between scores.

22 men and 8 women from the sports of athletics, swimming, and volleyball. All subjects were high-performance (national team athletes) or elite athletes (Olympians).

Procedures

All SJ trials were performed with data acquisition of 200 Hz from a combined force plate, linear position transducer and inter-faced software program that allowed for examination of the unfiltered data (Fitness Technology, Adelaide, Australia). The linear position transducer was calibrated using a 1-meter, purpose-built calibration pole. The force-plate is calibrated daily using a range of loads, in accordance with procedures developed for the National Sport Science Quality Assurance (NSSQA) program at the AIS. The SJ trials were performed with a knee angle of 90°, which was determined using a hand-held goniometer. Consistent with most SJ protocols, once the appropriate squat depth was achieved, an isometric hold of 3 seconds preceded the execution of the concentric jump.

Because there is some debate as to whether position transducers should be attached to a bar across the shoulders or attached to the waist via a belt (with the subjects hands placed on the hips), a pilot study was conducted to determine the reliability of performing squat jumps using both of these positions. An intraclass correlation (ICC) of 0.98 and percent technical error (%TE) of 2.19 was observed using the bar position, whereas an ICC of 0.87 and %TE of 3.71 was observed using the waist attachment. Furthermore, the subjects reported that the bar position felt "more comfortable" compared with the hands-on-hips position, and the subjects felt it was similar in nature to many movements performed in their strength and conditioning programs. As a result of this pilot study, the subjects performed the SJ trials with a 300-gram carbon fiber bar across the back of the shoulders to eliminate contribution of the arms, and to serve as an attachment point for the position transducer.

The subjects were all existing AIS scholarship holders and, as such, had been instructed on the execution of "no counter-movement" in squat jumping through their strength and conditioning programs, as well as through their routine testing of squat jumping. During both training and testing, subjects are advised and provided feedback on the proper execution of squat jumps, including the explanation of what constitutes a SACM.

In accordance with National Sport Science Quality Assurance standards for strength and power testing at the AIS, all subjects undertook a general warm-up routine that included jogging, ballistic stretching, and progressing submaximal to maximal trials of the test procedure. Subjects were allowed between 1 and 2 minutes' rest between each trial. Although the number of repetitions analyzed for each subject varied somewhat, all trials for an individual were recorded on the same day, and the entire pool of data collected spanned several weeks.

Statistical Analyses

Of the 125 trials analyzed in this investigation, total trials observed to have a SACM present by gross observation and detected by change in position using the position transducer were tallied. For the purposes of this investigation, "gross observation of a SACM" was defined as occurring when one or both of the researchers were visually able to detect a counter-movement (without observing the force-time trace, or position-time trace data).

All trials were also analyzed with the force-trace, with a SACM considered to be where a multiple sample (5-millisecond intervals) drop in force, greater than or equal to 10% of the athlete's body mass occurred, before the initiation of the upward propulsive phase of the jump (3). The efficacy of gross observation and the position transducer in determining a SACM were analyzed by comparing the percentage of trials from each method (gross observation and the position transducer) that were able to predict the SACM.

Results

During data collection, 69 trials (55.2%) were selected as having an observable countermovement by gross observation (researchers recorded that they visually observed a counter-movement prior to initiation of the concentric action). By analyzing the force-trace, 100% of these 69 trials were confirmed to have had a SACM present, ranging from a force unload of approximately 75–140 N.

In the force-trace analysis of the 56 remaining trials where no observable SACM was detected, it was observed that 43 of the remaining trials contained a force "unload" of >10% of the athlete's body mass. Therefore, our gross observation detected the presence of a SACM in 61.6% of the trials where a SACM occurred. A SACM occurred in 89.6% of all trials.

Analysis of the data from the linear position transducer used in this study demonstrated that in the 43 trials where VGRF demonstrated an unload, all but 1 of these trials also showed a change in displacement (indicating a SACM) based on displacement data obtained independently from the position transducer. Therefore, the linear position transducer detected a SACM in 99.2% of the trials where a SACM occurred.

Discussion

The aim of this investigation was to evaluate whether gross observation or a position transducer are adequate alternatives to using a force-plate to ensure compliance in proper SJ testing. This investigation was deemed to be worthwhile for three reasons: (1) At present, field-testing often involves performing SJ testing without instrumentation that can detect a SACM (4). In elite athletes, a SACM in the SJ can contribute to significant differences in jump height in comparison to SJ trials where the subject complied with proper SJ protocol. (3) For many strength and conditioning coaches, using a portable force plate in the field-testing setting is unrealistic.

Of the 125 SJ trials analyzed in this investigation, 89.6% contained a SACM and, of those trials, only 61.6% of these trials were observed to have a SACM present. Therefore, it is recommended that sport scientists do not rely on gross observation in administering SJ testing.

Results from the investigation indicate that the displacement-time graph provided by a linear position transducer can provide a precise method to ensure compliance in the SJ, in the absence of a force plate. Although a force plate is essentially the ideal standard of measurement of unloading and therefore a potential change in the C of G, position transducers appear to be an adequate alternative when conducting field testing outside of the laboratory, or when finances limit the capabilities of the sport-scientist to incorporate a force plate in the testing.

In agreement with previously collected data (Table 1), a comparison of SJ trials with and without a SACM revealed that for some subjects in this study, the presence of a SACM allowed for as much as a 6-cm increase in peak height achieved in the SJ when compared with the subject's trials that did not involve a SACM.

Practical Applications

Ideally, SJ testing should be monitored using a force plate to ensure compliance in the SJ. However, in the field this is not always possible. Considering that typical field-testing instruments such as the jump and reach apparatuses and jump ergometer do not provide the necessary data for appropriately identifying the presence of a SACM, it is recommended that the use of a linear position transducer be considered as an alternative to ensure compliance in squat jumps for circumstances where use of a force-plate is not possible.

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