Countermovement Jump Performance Is Not Affected During an In-Season Training Microcycle in Elite Youth Soccer Players

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Abstract

Malone, JJ, Murtagh, CF, Morgans, R, Burgess, DJ, Morton, JP, and Drust, B. Countermovement jump performance is not affected during an in-season training microcycle in elite youth soccer players. *J Strength Cond Res* 29(3): 752–757, 2015—This study examined the change in countermovement jump (CMJ) performance across a microcycle of training in professional soccer players during the in-season period. Nine elite youth soccer players performed a CMJ test before and after 4 consecutive soccer training sessions of an in-season weekly microcycle. Training load was quantified using global positioning systems, heart rate, and rating of perceived exertion. Absolute change (before to after training) in CMJ height across each training session was analyzed using one-way repeated-measures analysis of variance. Magnitude of effects was reported with the effect size (ES) statistic. Correlation analyses assessed the relationships between training load measures and the absolute change in CMJ height. Training load remained similar on all training days apart from a significant decrease in training load (all variables except high-speed distance) on the last training session ($p \leq 0.05$). No significant difference was found for CMJ height ($p = 0.23$) across the training microcycle (ES range, -0.04 to -0.22). No correlations were found between training load variables and absolute change in CMJ height (range: $r = -0.21$ to 0.22; $p > 0.05$). This study revealed no significant change in CMJ performance across the in-season microcycle. This finding suggests that soccer players are able to maintain CMJ performance across an in-season training microcycle.

Key Words periodization, training load, vertical jump, GPS, team sport

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Introduction

The assessment of neuromuscular status after intense exercise is important to understand the physiological impact of a given training stimulus (9). Measures of neuromuscular status in team sports in the applied setting have previously included various vertical jumps such as the countermovement jump (CMJ) and the squat jump (1,4,22). Previous studies using such protocols have reported impaired jump performance after competitive match play in Australian football (3,4), rugby league (22), and soccer (1,15,18). Although it is important to quantify jump performance after an acute bout of activity (such as a competitive match), it is also of interest to investigate the response to multiple bouts of exercise (such as training regimens). Impairments in jump performance may develop when fatiguing or damaging exercise is repeated consecutively over several days compared with an acute activity bout (4). Understanding the response to such patterns may be as important as one-off evaluations because of these protocols being more representative of the activity completed by athletes during weekly blocks of training.

In professional soccer, the microcycle is crucial for training load management in soccer teams. During the in-season period, soccer teams will typically use microcycles that emphasize recovery because of external factors related to the demands of competition (e.g., fixture scheduling (20)). If such microcycles are repeated longitudinally across a competitive season, then the physiological stimulus may be insufficient and lead to maladaptation (5). Maladaptation may also occur if training loads are consistently above those that are able to be tolerated by individuals within a group of players within a given team. This situation may be more problematic than low-intensity training programs, as it may lead to injury and an inability to take part in competitive fixtures. A detailed quantification of the impact of the training loads associated with soccer training can therefore provide useful information relating to the loading pattern that is used by soccer teams in preparation for a competitive match. If such physiological responses are well understood, it is more likely that players will go into training and matches better prepared to endure the demands of exercise. Previous research has examined the change in CMJ performance across different training microcycles in professional rugby league (17) in an attempt to provide a representation of individual player's readiness to perform during training and competition. The data in this study demonstrated that jump performance was significantly reduced during 4 days of the training microcycle. This highlights the potential use of CMJ for jump performance assessment during training microcycles. Currently, such data are not available from a weekly microcycle of soccer training in professional soccer players.

Therefore, the purpose of this study was to examine the change in CMJ performance across a microcycle of training in professional soccer players during the in-season period. In addition, training load variables across the microcycle were quantified and examined in relation to the change in CMJ performance. We hypothesized that there would be no significant change in CMJ performance because of the low training loads typically used during an in-season microcycle period.

Methods

Experimental Approach to the Problem

This study was designed to examine CMJ performance across multiple training sessions within a typical weekly training cycle in professional soccer. A CMJ test was selected as the measurement tool because of its functional nature and field-based capability. The absolute change in CMJ performance from pre- to postsession was determined for 4 consecutive soccer training sessions structured in a weekly microcycle in preparation for a competitive match. Each training session was classified in relation to the number of days before the competitive match (i.e., match day minus [MD−]). Thus, the 4 training sessions were broken down into: MD-4 (4 days before match), MD-3 (3 days before match), MD-2 (2 days before match), and MD-1 (1 day before match). This design was used to measure any potential changes in CMJ performance as a consequence of each training session and across the entire training microcycle.

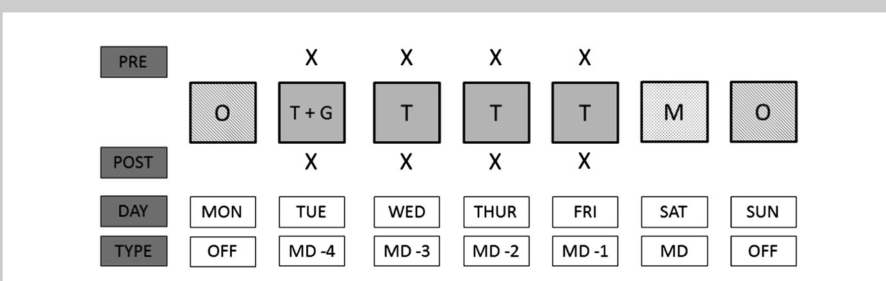

Figure 1. Outline of the experiment design. The weekly microcycle consisted of 4 individual training sessions structured in respect to the number of days before a competitive soccer match. Countermovement jump (CMJ) was assessed both before and after each individual training session. X = CMJ assessment; T = training day; G = team gym session; M = competitive match; O = day off; MD = match day.

A single training microcycle in March was selected for data collection during the 2012–2013 in-season competitive period. The microcycle represented the 39th week of the annual competitive cycle, which occurred with 7 weeks remaining in the cycle until the off-season phase. An outline of the study design is represented in Figure 1. All players were familiarized to perform a CMJ without arm swing before data collection. Familiarization was attained when a plateau (i.e., no significant change) in jump height was observed in consecutive trials. The coefficient of variation (CV%) was calculated from familiarization data for each individual player, with a plateau determined when the CV% of the data was below 5%. The number of sessions required for jump familiarization was 3 ± 1. The content of each training session was determined by the soccer coach and fitness coach of the team in line with the physical, tactical, and technical objectives for each given session. The session content was not in any way influenced by the researchers. Training sessions included physical, technical, and tactical practices. Training load was quantified using global positioning systems (GPS), heart rate (HR), and rating of perceived exertion (RPE). All soccer training and testing was performed at the soccer club's academy training facilities.

Subjects

Nine elite professional male youth soccer players were recruited to participate in the study. All players were part of an U18 soccer team within an elite soccer academy. Of these players, 7 have represented their respective countries at international level consisting of common playing positions (3 central defenders, 3 central midfielders, and 3 wide midfielders). The physical characteristics of the players (mean ± *SD*) were as follows: age, 16.4 ± 0.5 years (range, 16–17 years); height, 1.8 ± 0.6 m; body mass, 71 ± 9 kg; Yo-Yo Intermittent Recovery Test Level 2 Score, 29 ± 5 level. Written informed consent was given by each player, with the study being approved by the university ethics committee. Parental/guardian consent was given in line with the soccer team's policies.

Procedures

Countermovement Jump Performance. Countermovement jump performance was performed both before and after each individual training session across the microcycle. The CMJ test was performed according to previously described methods (19) using a portable photoelectric cell system (Optojump; Microgate, Bolzano, Italy). This equipment is both reliable and valid for vertical jump assessment (8,16). Results from these studies revealed a CV% of <6% and a standard error of the estimate of <1% compared with a biomechanical force plate. Jump height

TABLE 1. Training load data for individual soccer training sessions observed during a planned microcycle.*†

Training load variable	MD-4	MD-3	MD-2	MD-1
Duration (min)	103 ± 5	81 ± 8	76 ± 7‡	60 ± 0§
Total distance (m)	5,442 ± 619	5,212 ± 590	4,625 ± 688	3,688 ± 225§‖
Average speed (m·min^{-1})	53.1 ± 4.1¶	65.5 ± 5.1	61.2 ± 8.2	53.6 ± 3.3‖
High-speed distance (m)	106 ± 15	71 ± 73	44 ± 29	36 ± 37
HRmax (%)	71 ± 1	76 ± 3	68 ± 3	68 ± 1‖
RPE (AU)	3 ± 0¶	4 ± 1	3 ± 1	3 ± 1‖

*Data are presented in relation to the distance of the session from the next competitive match.
†MD− = match day minus; %HRmax = maximum heart rate; RPE = rating of perceived exertion.
‡Significant difference between MD-2 and MD-4.
§Significant difference between MD-1 and MD-4.
‖Significant difference between MD-1 and MD-3.
¶Significant difference between MD-4 and MD-3.

was calculated using the cell system software (Optojump Next v1.7.9; Microgate) and used for CMJ performance assessment. The highest jump was selected from the 3 repetitions completed in each trial for analysis. Players completed the CMJ testing in an indoor gym facility that provided a consistent stable flooring to minimize the influence of external factors (e.g., weather, foot-surface interaction). All players performed pretesting approximately 45–60 minutes before the outdoor training session. All players performed a standardized warm-up consisting of dynamic stretching and 3 submaximal CMJ efforts. No players completed any activity that could influence the outcome of the CMJ assessment between the pretest and the start of the training session. Posttesting was performed approximately 5 minutes after the completion of each training session.

Training Load Quantification. For all training sessions, each player wore a 10-Hz GPS device (Viper; Statsports, Dundalk, Ireland) inside a custom-made vest supplied by the manufacturer positioned on the upper back. Similar devices have previously demonstrated improved validity and reliability compared with earlier devices (i.e., 5 Hz devices) (16,23). For example, the reliability data revealed a lower CV% of <5% for low-velocity movements in 10-Hz devices compared with 5-Hz devices. The number of satellites connected was 10 ± 1 during all outdoor training data collection. The antennas of each unit were exposed to allow clear satellite reception (13). A custom-built GPS receiver and software application (Viper; Statsports) was used to time code each individual training session to determine training duration. The investigator manually clicked a button of the software to "stamp" the GPS data streaming at the beginning and end of each training session to obtain training duration. Player training data were subsequently downloaded using the manufacturer's software package and analyzed for the following variables: total distance covered, average speed (distance covered divided by training duration), and high-speed distance (distance covered above 5.5 m·s^{-1}). A technical fault with the GPS devices on one session resulted in the failure to collect data from 4 subjects. These subjects were excluded from the analysis of training load and jump performance for this session.

Players were also instructed to wear a portable HR belt (Polar T31; Polar Electro, Kempele, Finland). The percentage of maximum HR (% HRmax) was calculated for each player across each entire individual training session. After each training session, players were also asked to report their RPE score using

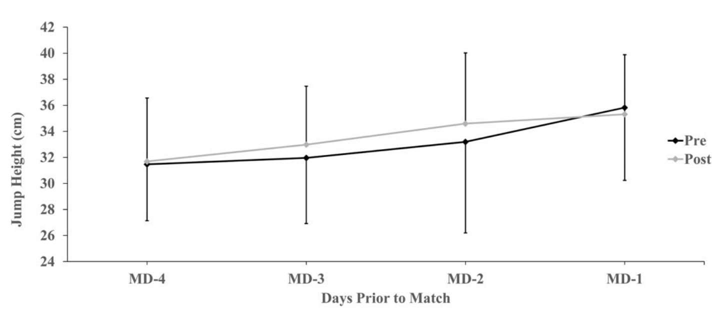

Figure 2. The differences in countermovement jump height during a microcycle represented by training session days before a competitive match. MD− = match day minus.

Table 2. Relationship between training load variables and absolute change in pre-to-post values of jump parameters during a planned microcycle of soccer training.*

	Jump height	
Training load variable	Correlation (r)	Significance
Duration (min)	−0.069	0.717
Total distance (m)	−0.003	0.986
Average speed ($m \cdot min^{-1}$)	0.122	0.520
High-speed distance (m)	−0.208	0.269
HRmax (%)	−0.063	0.740
RPE (au)	−0.153	0.419

*%HRmax = percentage maximum heart rate; RPE = rating of perceived exertion.

a previously established numerical scale (6). All players had regularly used this scale in the 6 months preceding the data collection period. The RPE score was collected within 15 minutes of the end of each training session for all players.

Statistical Analyses

The primary research question in this study was to examine if the change in CMJ performance (i.e., from pre-to-post training) is affected by the training load completed by players across a microcycle of training. With this in mind, a one-way repeated-measures analysis of variance (ANOVA) was selected to determine any differences in the change in CMJ performance (i.e., pre-to-post) across the training microcycle. The CMJ height was selected as the dependent variable, with training day (MD-4, MD-3, MD-2, and MD-1) set as the independent variable. To determine the differences for each training load variable (duration, total distance, average speed, high-speed distance, %HRmax, and RPE) across the microcycle, a one-way repeated-measures ANOVA was also used. Each training load variable was set as the dependent variable, with training day set as the independent variable. In the event of a significant F-ratio value being revealed, a Bonferroni's post hoc test was used to determine the significance between levels. The relationship between the training load variables and change in pre-to-post CMJ height was analyzed for all training sessions using Pearson's product-moment correlation coefficient (r). The effect size (ES) statistic was calculated to determine the magnitude of effects and was assessed using the following criteria: <0.2 = trivial, 0.2–0.6 = small effect, 0.6–1.2 = moderate effect, 1.2–2.0 = large effect, and >2.0 = very large (12). The 90% confidence intervals (CI) were also calculated using a statistical spreadsheet calculation (11). The normality of distribution of the data was checked using the Shapiro-Wilk test. Statistical significance was set at $p \leq 0.05$ for all tests used. Data are represented as mean ± SD. Analyses were performed using SPSS for Windows version 18 (SPSS Inc., Chicago, IL, USA).

Results

Training Load Quantification

The training load during the weekly microcycle is presented in Table 1. There were significantly higher values observed for duration on MD-4 compared with MD-2 (CI = 19.7 ± 33.9 minutes; ES = 4.47, very large; $p = 0.005$) and MD-1 (CI = 29.1 ± 38.1; ES = 8.85, very large; $p = 0.001$). Significant differences were also found for total distance values on MD-1 compared with both MD-4 (CI = 1,207 ± 2,302 m; ES = 3.77, very large; $p = 0.008$) and MD-3 (CI = 999 ± 2,049 m; ES = 3.77, very large; $p = 0.008$). Significantly higher values were observed for average speed on MD-3 in comparison with both MD-4 (CI = 7.0 ± 17.8 $m \cdot min^{-1}$; ES = 2.68, very large; $p = 0.001$) and MD-1 (CI = 6.8 ± 17.0 $m \cdot min^{-1}$; ES = 2.77, very large; $p = 0.004$). Similar observations were found also for RPE values, with MD-3 significantly higher in comparison with MD-4 (CI = 0.6 ± 1.8 au; ES = 2.40, very large; $p = 0.023$) and MD-1 (CI = 1.2 ± 2.4 au; ES = 3.29, very large; $p = 0.005$). There were significantly higher values found for %HRmax on MD-3 compared with MD-1 (CI = 5 ± 11%; ES = 3.58, very large; $p = 0.027$). There were no differences observed between training sessions for high-speed distance ($p > 0.05$).

Countermovement Jump Performance

The differences in CMJ height from pre-to-post each individual training session are represented in Figure 2. There was no significant difference between prejump and postjump height values on MD-4 (CI = −4.0 ± 3.6 cm; ES = −0.04, trivial), MD-3 (CI = −4.9 ± 2.9 cm; ES = −0.21, small), MD-2 (CI = −6.5 ± 3.7 cm; ES = −0.22, small), and MD-1 (CI = −3.7 ± 4.7 cm; ES = 0.10, trivial) (all $p > 0.05$).

Countermovement Jump Performance and Training Load Relationship

The relationship between the absolute change in pre-to-post CMJ height and each training load variable is detailed in Table 2. There were no significant correlations found between absolute change in jump height and any of the training load variables ($p > 0.05$).

Discussion

The aim of this study was to examine the change in CMJ performance across a microcycle of training in professional soccer players during the in-season period. In addition, training load variables across the microcycle were quantified and examined in relation to the change in CMJ performance. We hypothesized that there would be no observed change in CMJ performance because of the focus of training during the in-season phase on the maintenance of players physical capacities. Our results are in agreement with the original hypothesis, with no significant differences observed in CMJ performance across the training microcycle. There were significant differences observed in training load variables across the microcycle, with MD-1 reporting lower values for duration, total distance, average speed, %HRmax, and RPE in comparison with MD-4 and MD-3. There was also no relationship found between training load and CMJ performance. This would suggest that the training load used did not influence the change in CMJ performance across the training microcycle. Our results suggest that CMJ performance remains unaffected during an in-season microcycle in professional soccer, possibly because of the training load patterns used by the soccer coaches.

An analysis of the representativeness of the training loads completed by the players in this study is important. The participants in the study were elite youth academy players, and as such, it is acknowledged that the training performed may be different from that completed by other soccer playing populations. Such limitations may influence the ability to generalize the findings from this research to other soccer players. The overall training schedule and training session duration in our research was similar to those observed in Danish, Korean, and English professional soccer teams during the in-season periods (2,7,14,21). In terms of external load measures, the average speed values in this study averaged 58.6 $m \cdot min^{-1}$ across the microcycle. Such values were 12% lower than those reported in an elite senior English soccer team, with average values of 66.6 $m \cdot min^{-1}$ across the in-season period (7). The amount of high-speed distance covered was also 46% lower in this study (mean, 64.3 m) in comparison with elite senior English soccer players (mean, 118.8 m) (7) using the same velocity banding. In terms of internal load measures, the weekly combined RPE-based load (RPE $\times$ duration) in this study was 1,041 au, which was 39% lower than those reported in elite senior Korean soccer players (mean, 1,703 au) (14). The mean %HRmax across the microcycle in this study was 71%, which was 13% higher than the values reported in elite senior Korean players (mean, 58%) (14). When taken together, it seems that the training loads used in elite youth soccer is significantly lower than that of elite senior soccer teams. This may be due to the emphasis on coaching points, which result in multiple stoppages during training and reduce the overall training intensity. Therefore, the findings of this study may be limited to elite youth soccer populations, with further data being required to quantify such training loads in senior teams.

There was no observed change in CMJ performance across the microcycle of training analyzed in the current investigation. The mean difference in jump height between prevalues and postvalues across the training microcycle was only 0.5 cm, which equated to a 2% difference in values. One key factor that may determine the change in CMJ performance in soccer players is the specific training prescription used to develop the session completed by the players. During the in-season period, the physical focus of training will predominantly relate to the maintenance of fitness levels and ensuring that players are fully recovered in between competitive matches (20). Soccer coaches therefore seem to typically use training loads that preserve fitness (i.e., external training load that maximizes recovery while maintains current physiological status (24)) and have a tactical focus as opposed to designing training stresses that attempt to physiologically overload the players for fitness improvement. It could be argued, therefore, that CMJ performance was not altered in this study, as the players were accustomed to the completion of such loading patterns through the repeated exposure to similar patterns of volume and intensity throughout the in-season phase. If repetitive loading patterns are repeated longitudinally during the in-season phase, then the chance of training monotony and subsequent risk of injury/maladaptation may increase (5). Therefore, it is important that soccer practitioners quantify training load longitudinally while also monitoring the physiological performance response across each individual player.

The lack of change in CMJ performance across the training microcycle could alternatively be a consequence of the inability of the methodology used to track small, yet potentially important, changes in the force-generating capabilities of muscle. This may be a direct consequence of the "noise" associated with such field-based assessment strategies. In experimental designs in which the external loading is higher than that observed in the soccer training analyzed in this article (i.e., a soccer match) CMJ performance is significantly reduced (1,10,18). Such reductions in CMJ height are around −8.2% from pre-to-post assessments (a reduction in peak power of around −15.5%). Countermovement jump height, in this study, was only reduced on MD-1 by −1.4%. Such small differences in CMJ performance are below the test-retest values of such procedures in our laboratory (jump flight time = 3.2 CV%; jump height = 5.6 CV%). This makes it very difficult to accurately determine whether such changes are meaningful to the performance of an athlete. This information suggests that although the CMJ test is able to detect significant alterations in CMJ performance after a soccer match, the subtle alterations in physiological status observed with soccer training may remain undetected. This suggests that future research should attempt to develop protocols that are able to establish the meaningfulness of such small changes in performance in the field.

When interpreting the findings of this study, several limitations exist because of the applied nature of the research study. First, only a small sample size ($n = 9$) was used for this study, which may affect the statistical significance for some of the findings. This was due to a lack of availability of elite-level subjects for testing, something, which is regularly encountered in applied research projects. Second, only 1 weekly microcycle was selected for data collection and analysis, limiting the findings to one particular week during a 40-week in-season period. This research design was selected, as it deemed that it represented a "typical" in-season weekly microcycle. However, future work should look to examine the training load and CMJ performance response over a longer period characterized by different levels of training load to understand the physiological response in more detail. Future research could also look to establish the differences between players who do not play in competitive matches (i.e., nonstarters) compared with players who regularly play (i.e., starters). This would provide further detail regarding the individual training load management of players and the subsequent physiological response.

Practical Applications

The findings of this study may have several practical implications for the planning of training structure in soccer teams. The lack of change in CMJ performance across the training microcycle suggested that the soccer players are not physiologically taxed by the training sessions delivered within the in-season period. This may indicate that coaches are aware of the potential problems of delivering repeated bouts of intense training when preparing for competitive fixtures and subsequently use maintenance-type loading. Another possible implication from the present findings is the inability of field-based jumping protocols to detect meaningful alterations in CMJ performance in response to soccer training. This may have implications for the strategies used within the applied environment to monitor the readiness of players to complete either training sessions or competitive matches. For the strength and conditioning professional, it is important to use tools in the field that adequately monitor training load and the subsequent physiological response to maximize athlete potential.

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