Individual changes in countermovement jump performance in national youth track and field athletes during an indoor season

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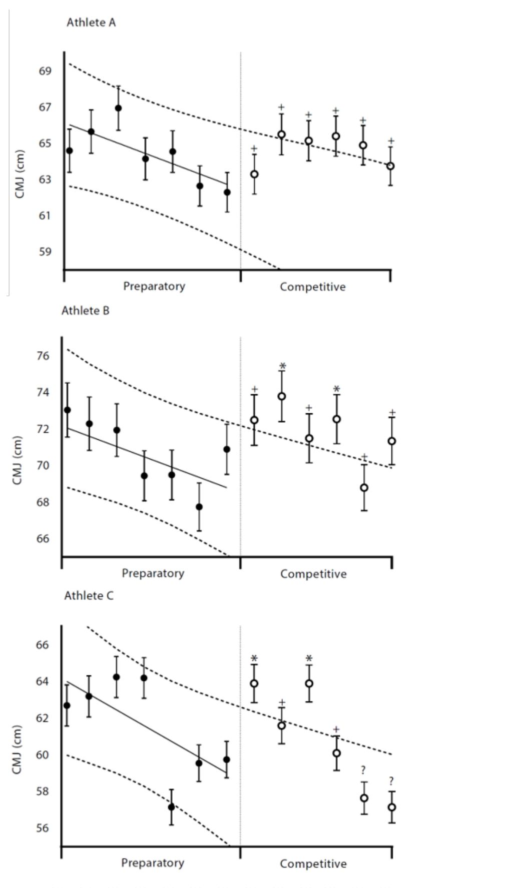

Fig. 1. Individual changes in CMJ performance from preparatory period in athlete A, B and C, respectively. Dashed lines show the SWC plus the typical error in the predicted true value, while the black line the predicted score from the trend. Black and white dots represent the vertical jump height (± typical error of measurement) during the competitive and preparatory period, respectively (* :very likely; + :possibly higher / trivial; ? : unclear).

Headline

Countermovement jump (CMJ) has been used as marker for monitoring neuromuscular readiness in several sport settings (1,2,3). In athletics, previous investigations analysed the seasonal changes in CMJ test showing an increase in jump height before the season best result in senior (4) and elite athletes (5), while no data are yet available on the individual trend of CMJ performance in young athletes over a competitive season. Therefore, longitudinal studies investigating monitoring approaches in young athletes are warranted to assist coaches in designing appropriate training programs (6).

Aim. The aim of this case study was to investigate the individual trend and changes in vertical jump performance in young national track and field athletes using a magnitude-based inference approach (7). The purpose for practitioners was to illustrate whether vertical jump test can be used as a monitoring tool to assess athletes' neuromuscular readiness during the competitive period.

Methods

Athletes. Three national track and field athletes (age 16.5 ± 0.6 years; stature 180.7 ± 6.8 cm; body mass 67.7 ± 2.8 kg; long jump personal record 7.02 ± 0.28 m) representative of an athletics academy participated in the study. The athletes competed in four long jump national competitions during the 2018 indoor athletics season. Written informed consent was obtained from participants along with parental consent. The study is conformed to the recommendations of the Declaration of Helsinki (8).

Design. Case study. Athletes were investigated during the entire indoor season (13 weeks), which is composed by a preparatory (week 0-6) and a competitive (week 7-12) period. Within the competitive period, week 8, 9, 10 and 12 were considered as competitive weeks, in which athletes took part in national indoor long jump competitions. During the investigated periods, athletes were involved in 2-to-4 training sessions per week, plus one long jump competition during the competitive weeks. Despite the competitive period, the coaching staff maintained a high training load profile with the aim of achieving performance peak later in the outdoor season. Weekly training and competition workloads are displayed in Table 1.

Methodology. CMJ performance was monitored on a weekly basis during the investigated period. Testing sessions were performed on the first training session of the week ensuring 48h of recovery from the last training session and/or competition. After a 15-min standardized warm up, the CMJ test was administered using the OptoJump Next (Microgate, Bolzano, Italy), according to previously outlined procedure (9). Each athlete performed two trials separated by 2-min passive rest. Considering the monitoring purpose of the measurements, averaged scores were calculated for the analysis as previously suggested (3).

Statistical Analysis

Weekly changes in CMJ performance over the indoor season were analysed using a magnitude-based inference approach (10). Linear trend and changes in CMJ performance were assessed against the smallest worthwhile change (SWC) and typical error (TE) on a customized excel spreadsheet (7). SWC, TE and degrees of freedom were obtained from a between-day

Table 1. Training and competition workloads of the athletes during the indoor season.

Activity Profile	Athlete	Preparation period							Competitive period						Mean ± SD	
		W0	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	Preparatory	Competitive
Frequency (sessions/week)	A	4	4	3	4	4	4	2	4	5(1)	4(1)	4(1)	3	4(1)	3.5 ± 0.8	4.0 ± 0.6
	B	4	3	3	4	4	2	2	4	5(1)	3(1)	5(1)	3	3(1)	3.0 ± 0.9	3.8 ± 1.0
	C	4	4	3	4	4	4	2	4	5(1)	4(1)	4(1)	3	4(1)	3.5 ± 0.8	4.0 ± 0.6
Duration (hours/week)	A	8	8	6	8	8	8	4	8	10(2)	8(2)	8(2)	6	8(2)	7.0 ± 1.6	8.0 ± 1.3
	B	8	6	6	8	8	4	4	8	10(2)	6(2)	10(2)	6	6(2)	6.0 ± 1.8	7.7 ± 2.0
	C	8	8	6	8	8	8	4	8	10(2)	8(2)	8(2)	6	8(2)	7.0 ± 1.6	8.0 ± 1.3

W: week; Preparatory period: from W0 to W6; Competitive period: from W7 to W12; Competition load is indicated in brackets in W8, W9, W10, W12.

Table 2. Athletes characteristics, long jump best performance, seasonal average CMJ (mean ± SD), SWC and TE for each athlete.

Athlete	Age (year)	Statute (cm)	Body mass (kg)	Long Jump PB (m)	CMJ (cm)	SWC (%)	TE (%)
Athlete A	16.7	173	64.5	6.73	64.5 ± 1.3		
Athlete B	17.0	186	69.5	7.04	71.2 ± 1.9	3.9	2.8
Athlete C	15.8	183	69	7.28	61.1 ± 2.8		

PB: personal best; CMJ: countermovement jump; SD: standard deviation; SWC: smallest worthwhile change; TE: typical error. SWC and TE are obtained from a between day reliability study performed in youth sports athletes (11).

reliability study investigating youth sport athletes (11). To assess the changes from linear trend, data from the preparation period (week 0-6) were included to fit a straight-line trend (baseline) in order to calculate possible changes between preparation and competitive period. Average changes from linear trend were calculated including the measurements performed during the weeks of national competitions only (competitive weeks). Finally, week-to-week changes were calculated for the entire indoor season. Chances of real differences in variables were assessed qualitatively as <10% very unlikely; 10-90% possibly, and >90% very likely. Clear effects greater than 90% were considered substantial (7). If the chances of a variable having higher and lower differences were both >10%, the true effect was deemed to be unclear (7, 10).

Results

Athletes characteristics and seasonal average CMJ performance are displayed in Table 2. Changes in CMJ performance from preparatory period are displayed in the Figure 1A, 1B and 1C for athlete A, B and C, respectively. Athlete A did not show substantial changes (*possibly higher/trivial*) in CMJ performances compared to preparatory period. Athlete B showed *very likely* higher CMJ performances on week 8 [93/6/0] and 10 [91/9/0], while athlete C displayed *very likely* higher CMJ performance on week 7 [90/9/0] and week 9 [93/6/1]. A *very likely* higher competitive weeks' average CMJ performance was shown for athlete B [93/6/0] compared to preparatory period, while athlete A [*possibly higher/trivial* - 85/15/0] and athlete C [*possibly higher/trivial* - 79/19/3] showed no substantial differences. The analysis of week-to-week changes in CMJ performance indicated *unclear* and no substantial differences through the entire season for athlete A and B, while athlete C showed a *very likely* lower CMJ performance in week 4 compared to week 3 [0/3/97].

Discussion

This case-study demonstrated that U18 national track and field athletes showed different individualized responses in CMJ performance between the preparatory and competitive period. Athlete A exhibited no substantial variations, while athlete B and C displayed substantial higher CMJ values during the first part of the competitive period (week 7-8-9-10). These findings are in line with previous studies investigating vertical jump performance in senior track and field power-event athletes (4) and elite middle-distance runners (5) showing higher CMJ scores over the competitive period. The higher CMJ values at the beginning of the competitive period might be explained by a reduced number of training sessions in week 6, which was adopted as recovery week to increase athletes' performance in the competitive period (12). However, interestingly CMJ performance tends to decrease toward the end of the competitive period possibly due to the accumulation of training and competition workloads, which has been previously shown to decrease the performance in different sport settings (13, 14). Indeed, as previously mentioned, the coaching staff likely kept a high workload during the indoor season to reach the peak performance later during the outdoor season. Considering the competitive weeks only (week 8-9-10-12), the average change in CMJ from the preparatory period highlighted substantial (athlete B) and possible (athlete A and C) changes suggesting vertical jump measures as a sensitive tool to monitor individual performance over the competitive period. Overall, no substantial weekly changes in CMJ were reported during the competitive period except for athlete C, who exhibits a substantial decrease from week 3 to 4. In conclusion, CMJ test might be considered a useful monitoring tool for optimizing individualized athlete training load prescription (4) to likely avoid overtraining symptoms and attenuate the risk of injury. Further studies should deepen the development of neuromuscular fatigue over the competitive season to identify recovery and performance optimization strategies in track and field athletes using individual approaches.

Practical Applications

- Within the context of young athletes competing in jumping events, the CMJ test performed on a weekly basis might be a practical and useful tool to assess individual neuromuscular readiness across the season and to compete at their best;
- In contrast to the single weekly measures, the average CMJ scores during the competitive weeks in comparison to the

preparatory period's trend can be used as sensitive measure to monitor performance preparedness by coaches and sport scientists;
- An individual-based magnitude inference approach can be an effective way to identify changes in vertical jump performance over an athletics season in youth long jumpers.

Limitations

- The trend-line selected to compare the preparation and competitive periods is quite unstable due to the variations in training volume and intensity during the preparatory period.
- No data of external and internal training load were collected except for the number of sessions and their respective durations. Monitoring CMJ together with external and internal training load might provide information more valuable for track and field coaches to set up appropriate training strategies and maximize performance.
- SWC, TE and degrees of freedom were obtained from a between-day reliability study performed within youth team sports athletes (11) lacking of specificity for youth track and field athletes.
- Results investigated the use of CMJ as fatigue monitoring tool in U-18 long jump athletes performing in long jump only. Due to the relationship between vertical jump measure and athletics performance in power events (i.e. 100m, long jump) (15), further studies should assess weekly performance changes in youth athletes competing in different track and field events.

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