The Relationships Between Internal and External Training Load Models During Basketball Training

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Abstract

Scanlan, AT, Wen, N, Tucker, PS, and Dalbo, VJ. The relationships between internal and external training load models during basketball training. *J Strength Cond Res* 28(9): 2397–2405, 2014—The present investigation described and compared the internal and external training loads during basketball training. Eight semiprofessional male basketball players (mean ± *SD*, age: 26.3 ± 6.7 years; stature: 188.1 ± 6.2 cm; body mass: 92.0 ± 13.8 kg) were monitored across a 7-week period during the preparatory phase of the annual training plan. A total of 44 total sessions were monitored. Player session ratings of perceived exertion (sRPE), heart rate, and accelerometer data were collected across each training session. Internal training load was determined using the sRPE, training impulse (TRIMP), and summated-heart-rate-zones (SHRZ) training load models. External training load was calculated using an established accelerometer algorithm. Pearson product-moment correlations with 95% confidence intervals (CIs) were used to determine the relationships between internal and external training load models. Significant moderate relationships were observed between external training load and the sRPE ($r_{42} = 0.49$, 95% CI = 0.23–0.69, $p < 0.001$) and TRIMP models ($r_{42} = 0.38$, 95% CI = 0.09–0.61, $p = 0.011$). A significant large correlation was evident between external training load and the SHRZ model ($r_{42} = 0.61$, 95% CI = 0.38–0.77, $p < 0.001$). Although significant relationships were found between internal and external training load models, the magnitude of the correlations and low commonality suggest that internal training load models measure different constructs of the training process than the accelerometer training load model in basketball settings. Basketball coaching and conditioning professionals should not assume a linear dose-response between accelerometer and internal training load models during training and are recommended to combine internal and external approaches when monitoring training load in players.

Key Words team sport, court-based sport, exercise, heart rate, accelerometer

Introduction

The implementation of techniques to monitor athlete responses to training stimuli is pertinent to the team-sport coach and conditioning professional. Measurement of athlete training loads provides objective evidence for the management of training variation, which might allow greater precision and control of periodized conditioning plans along with a reduced incidence of overtraining (23). Accordingly, various methods of monitoring internal (5,16,18) and external (9,15) training load in team-sport athletes have emerged.

The internal training load represents the physiological stress imposed on the athlete in response to the training stimulus (e.g., perceptual rating of intensity, heart rate [HR], hematological measures) (33,34). Meanwhile, quantification of the physical training stimulus detached from the internal response of athletes indicates the external training load (e.g., training duration, distance traveled, running speed, and body accelerations) (33,34). To date, internal training load models incorporating perceptual (3,18,22) and physiological (3,5,16) parameters have been the most widely used in team sports. Specifically, Foster et al. (18) developed a training load model incorporating perceptual indicators of exercise intensity through the session rating of perceived exertion (sRPE) and exercise duration. Moreover, Bannister (5) proposed a physiological training load model based on resting, mean, and maximum HR responses and exercise duration, identified as the training impulse (TRIMP). Similarly, Edwards (16) put forward the summated-heart-rate-zones (SHRZ) model that determines training load based on the duration spent working in predetermined HR ranges. These models have been applied in field-based team sports, including Australian rules football (34), rugby league (19), and soccer

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(2,3,22). However, limited internal training load data exist for court-based team sports, such as basketball (25).

Training load approaches need to be determined for each sport and should address the specific demands encountered by players in that sport. Recent time-motion data indicate that the high-intensity intermittent nature of basketball game play, combined with the requirement to perform sport-specific activities such as dribbling, shuffling, positioning, and cutting maneuvers, impose a unique set of demands on basketball players (7,29,30). Consequently, it is important that the efficacies of established training load models are assessed during basketball training so that appropriate workload monitoring practices can be adopted in the sport. To date, internal training load responses have largely been reported during isolated training sessions (18) or game play (27) in basketball players. Only one investigation could be identified reporting on training load responses across repeated training sessions in basketball players (25). Manzi et al. (25) observed significant relationships ($r = 0.69$–0.85, $p < 0.001$) between the sRPE and HR-based training load models in professional male basketball players during in-season training. Although Manzi et al. (25) provide novel findings regarding the use of internal training load models, comparisons with these models and external training load are yet to be reported in basketball. Measurement of the external training load in basketball is warranted given both internal (e.g., sRPE, HR, and hematological measures) and external responses (e.g., movement distances, speeds, and accelerations) have been suggested to comprise the complete training process (33,34). More specifically, the internal and external training loads have been likened to the training response and dose, respectively (33,34). As such, assessing the commonality of popularized internal training load models with externally derived measures of the training stimulus provides insight into the construct validity of internal models (34), which has been examined in various other team sports (11,33,34).

Currently, a paucity of research has examined external training load models in basketball, possibly because of the limitations associated with popular approaches used in other team sports. For instance, the labor-intensive nature of time-motion video analyses (15), and the signal interference (26) and inaccuracies (14) associated with global positioning system (GPS) use during indoor court-based sports, limit the applicability of these methods to basketball. Alternatively, accelerometry overcomes many of the aforementioned limitations of other approaches to monitor external training load and has received increased interest as a practical approach to measure external training load in team sports (11,33,34). A triaxial accelerometer training load model has been developed that involves vector magnitude calculations of the instantaneous rate of change in acceleration in the 3 movement planes (8,26). Given that basketball-specific activity typically involves whole-body displacement in forward, backward, lateral, and vertical directions, the accelerometer training load model is suited to monitor external training load during basketball training (26). However, to date, the accelerometer training load model has only been used to differentiate the physical demands experienced by elite junior male basketball players during different individual drills (26). Subsequently, the accelerometer training loads experienced by basketball players during repeated complete training sessions typically performed across the annual training plan are yet to be elucidated. Furthermore, this approach might provide a practical approach in basketball settings against which comparisons with common internal training load models can be made.

The provision of these data will provide important practical insight regarding the construct validity of various internal training load models through comparisons with external training load in basketball settings. The aim of this study was to describe and compare the internal (sRPE model, TRIMP, and SHRZ models) and external training loads (accelerometer model) encountered during basketball training. Given previous team-sport studies have shown player response to significantly ($p \leq 0.05$) correlate with concomitant training stimuli ($r = 0.72$–0.84) (11,33,34), it was hypothesized that internal and external training load models would be strongly related and possess high shared variance ($R^2 > 50\%$) during basketball training.

METHODS

Experimental Approach to the Problem

Players were monitored during the general and specific preparatory phases of the annual training plan. The activities performed during each of the training phases are detailed in Table 1. Player sRPE and HR were collected across all training sessions to calculate internal training load responses. In addition, player accelerometer outputs were obtained across all training sessions to calculate external training load. All outdoor and indoor training sessions were conducted in similar ambient conditions (temperature: 26.4 ± 1.8° C; relative humidity: 73.4 ± 10.8%).

Subjects

Eight semiprofessional male basketball players (mean ± *SD*, age: 26.3 ± 6.7 years (range: 19-37 years); stature: 188.1 ± 6.2 cm; body mass: 92.0 ± 13.8 kg) volunteered for this study. Players were competing in the Queensland Basketball League, which forms part of a state-level, second tier Australian basketball competition. Before commencement of the study, all participants were screened for health conditions and injuries that contraindicated participation. The aims, procedures, risks, and benefits of the study were explained to all participants before they voluntarily gave informed consent. All research procedures were granted prior approval by an Institutional Human Research Ethics Committee in accordance with the Helsinki declaration.

Training load data were collected across a mean (±*SD*) of 5.5 ± 2.8 sessions for each player (range of 2–9 sessions),

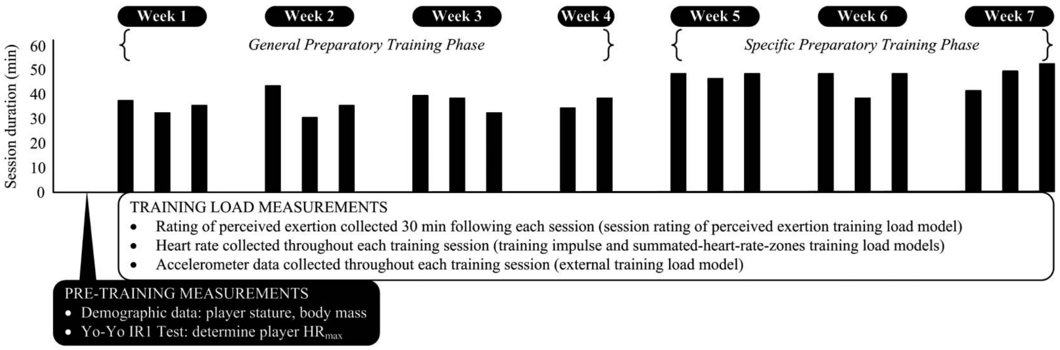
Table 1. The training activities performed during the general and specific preparatory phases of the annual training plan.

Training phase	Training activities	Training goals
General preparatory	Repeated linear running	Stress a combination of energy systems for metabolic adaptation
	Repeated linear sprinting	Increase emphasis on high-intensity work with training progression
	Intermittent linear running drills	Improve running and sprint technique
Specific preparatory	Speed and footwork drills using cones and ladders	Develop physical and cognitive agility qualities
	Visual opponent-based reaction drills	Develop on-court speed in multiple directions
	Upper-body power drills using medicine balls	Improve lower- and upper-body power qualities
	Lower-body power drills using jumps and hurdles	Improve anaerobic metabolic conditioning
	Repeated multidirectional running and sprinting	Develop intermittent endurance
	Multidirectional shuffling drills	Develop skills in key areas
	Intermittent running drills (with and without ball)	
	Offensive and defensive skill-based drills	

resulting in 44 total sessions being examined. Data for each player were included in the analyses if (a) the player completed the entire training session and (b) useable sRPE, HR, and accelerometer responses were gathered in combination for the player.

Procedures

Demographic information was initially collected for each player, including body mass (digital medical scales, model BWB-600; Tanita Corporation, Tokyo, Japan) and stature (digital stadiometer, model 274; Seca, Hamburg, Germany). Polar Team2 Pro HR monitors (Polar Electro Oy, Kempele, Finland) were affixed to each player before all testing and training sessions. Player HR responses were sampled at 1-second intervals, recorded onto the monitors of each player, and externally downloaded to a personal computer after each session for analysis using Polar Team2 software (Polar Electro Oy). Before training load assessment, players completed a Yo-Yo intermittent recovery test (level 1) to determine individual maximum HR response (HR_{max}) as



TRAINING LOAD MEASUREMENTS
- Rating of perceived exertion collected 30 min following each session (session rating of perceived exertion training load model)
- Heart rate collected throughout each training session (training impulse and summated-heart-rate-zones training load models)
- Accelerometer data collected throughout each training session (external training load model)

PRE-TRAINING MEASUREMENTS
- Demographic data: player stature, body mass
- Yo-Yo IR1 Test: determine player HR_{max}

Figure 1. A schematic representation of the testing and training schedule followed in this study. Yo-Yo IR1 = Yo-Yo intermittent recovery test (level 1); HR_{max} = maximum heart rate; session warm-up and cool-down not included in session duration.

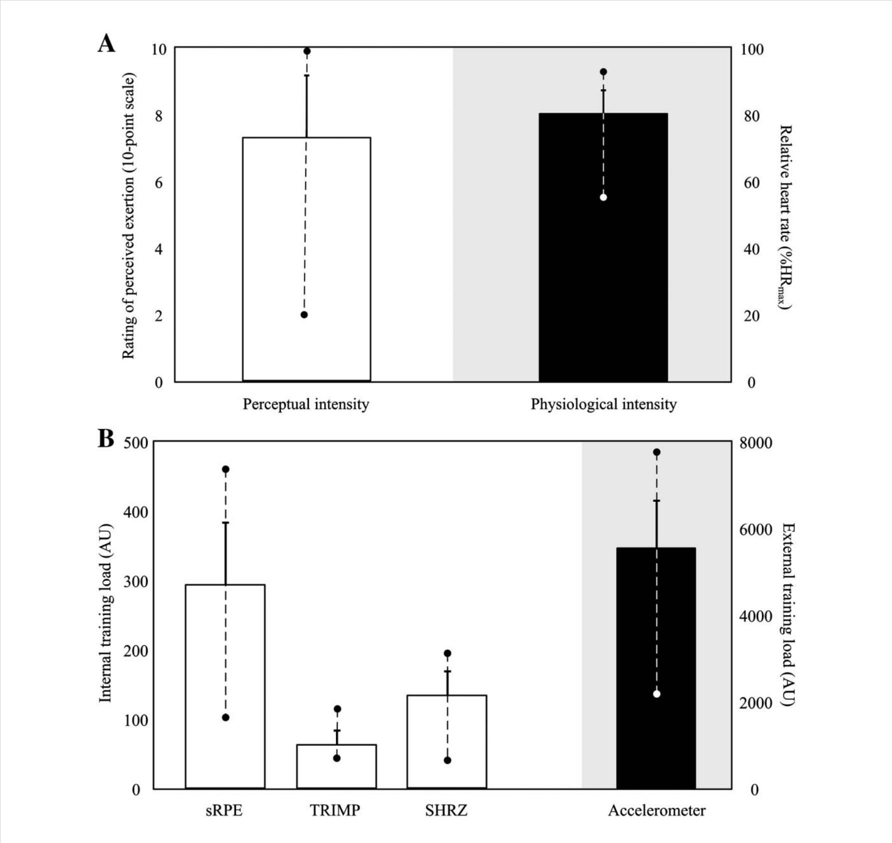


Figure 2. The mean ± *SD* (A) perceptual and physiological training intensities and (B) internal and external training loads during the preparatory training phase in semiprofessional basketball training ($n = 44$). $\%HR_{max}$ = percentage of maximum heart rate; AU = arbitrary units; sRPE = session rating of perceived exertion model; TRIMP = training impulse model; SHRZ = summated-heart-rate-zone model; dashed line = data range across training sessions.

previously used in training load studies (25,33). The reliability of the Yo-Yo intermittent recovery test (level 1) has been previously supported (coefficient of variation [CV] = 4.9%) (24). In addition, HR was measured across a 2-minute period in a rested condition for each player to determine individual resting HR (HR_{rest}) (5,25,33). Before each team training session, players performed a 15-minute standardized warm-up, involving low-intensity jogging, whole-body dynamic stretches, and brief bouts of high-intensity running. A schematic overview of the training and testing design of this study is shown in Figure 1.

Perceptual and physiological models were used to measure internal training load. Perceptual training load was determined using the sRPE model (18). The sRPE model calculates internal training load (in arbitrary units [AU]) as the product of training duration and training intensity, whereby intensity is computed from a modified 10-point rating of perceived exertion scale (18). Each player was familiarized with the RPE scale during previous training sessions and provided their rating 30 minutes after the completion of each training session (18). The sRPE model has been previously used to monitor internal training load across a number of team sports (2,25,34).

Physiological training loads were determined through player HR data applied to the TRIMP (5) and SHRZ (22) training load models. The TRIMP model combines player HR_{max}, HR_{rest}, and average HR during training (5). Activity intensity is weighted using a previously developed fixed exponential relationship between changes in HR and blood lactate concentration reported for incremental exercise (5). Conversely, the SHRZ model combines activity duration and activity intensity, which is weighted according to 5 discrete HR zones relative to HR_{max}. A multiplier accompanies each HR zone that places greater weighting on higher relative HR responses (22). Previously, the TRIMP (2,3) and SHRZ (25,34) models have been used to determine internal training load in team-sport athletes. The following formulae were applied to determine internal training load using the (a) TRIMP (5) and (b) SHRZ (22) models:

$$\text{TRIMP training load (AU)} = (\text{Duration [minute]}) \times (HR_{ex} - HR_{rest}) \Big/ (HR_{max} - HR_{rest}) \times 0.64e^{1.92x},$$

where HR_{ex} = average HR during exercise; HR_{rest} = HR at rest; HR_{max} = maximal HR; $e = 2.712$; and $x = (HR_{ex} - HR_{rest})/(HR_{max} - HR_{rest})$.

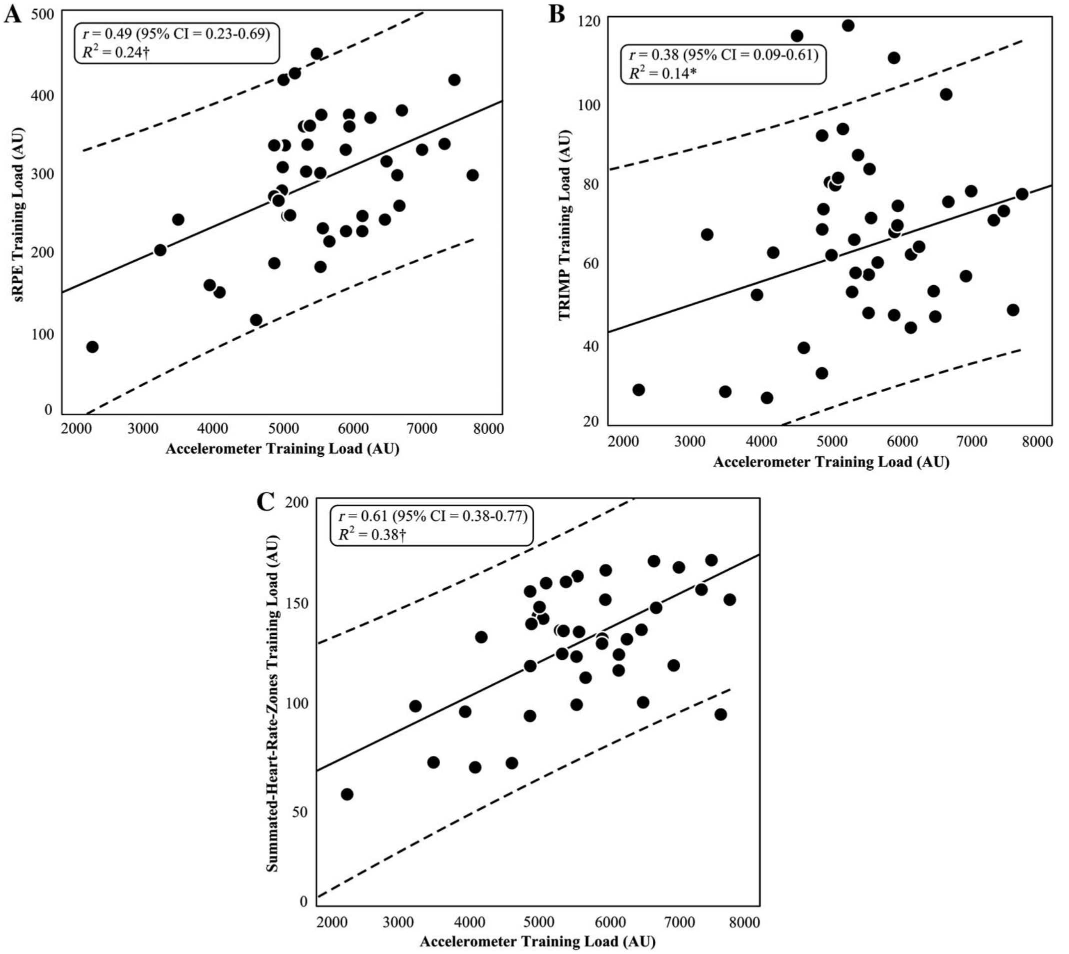


Figure 3. Correlations between external training load (accelerometer model) and (A) session rating of perceived exertion (sRPE) model, (B) training impulse (TRIMP) model, and (C) summated-heart-rate-zones model during semiprofessional basketball training ($n = 44$). AU = arbitrary unit; 95% CI = 95% confidence intervals; * denotes $p \leq 0.05$; † denotes $p \leq 0.001$.

$$\begin{aligned}\text{SHRZ training load (AU)} = {} & (\text{duration in zone } 1 \times 1) \\ & + (\text{duration in zone } 2 \times 2) \\ & + (\text{duration in zone } 3 \times 3) \\ & + (\text{duration in zone } 4 \times 4) \\ & + (\text{duration in zone } 5 \times 5),\end{aligned}$$

where zone 1 = 50–60% HR_{max}; zone 2 = 60–70% HR_{max}; zone 3 = 70–80% HR_{max}; zone 4 = 80–90% HR_{max}; zone 5 = 90–100% HR_{max}.

External training load was determined using 4 triaxial accelerometers (model MMA7361L; Freescale Semiconductor, Inc., Austin, TX, USA) positioned on the posterior surface of the torso at the level of the inferior angle of the scapulae. Each accelerometer was affixed to a breakout board with a Logomatic data logger (version 2; SparkFun Electronics, Boulder, CO, USA), which transferred the data to a SD memory card. Accelerometers were secured to each player through customized pouches attached to the HR monitor chest bands. Accelerometer placement at this location minimized the risk of player contact injuries and infrastructure damage. Our accelerometer placement positioned the device closer to the body's center of mass compared with placement locations typically seen with the use of vests (9), which proved advantageous given positioning the accelerometer closer to a player's center of mass has been demonstrated to better represent whole-body movement (26). Each accelerometer had a full-scale output range of ±6*g* and sampled at a rate of 100 Hz. Whole-body movements were determined as the accumulated instantaneous rate of change in acceleration in the 3 movement planes (anteroposterior, mediolateral, and craniocaudal) (9). External training load was then calculated using an established algorithm developed by Catapult Innovations (Scoresby, Australia). Previously, this model has been frequently used to determine external training load in team-sport athletes (9,33). LabVIEW software (v2013; National Instruments, Austin, TX, USA) was used to calculate external training load by the following formula (8,11):

$$\text{External training load} = v\Big[(a_{y1} - a_{y1-1})2 + (a_{x1} - a_{x1-1})2 + (a_{z1} - a_{z1-1})2\Big]\Big/100,$$

where a_y = anteroposterior acceleration; a_x = mediolateral acceleration; and a_z = craniocaudal acceleration.

Pilot data supported the reliability (intraclass correlation coefficient [ICC] = 0.92; standard error of the mean [SEM] = 256.3 AU) of the accelerometer training load model in semi-professional basketball players ($n = 6$) during volume-matched, field-based repeated running and sprinting activities across varied distances. Furthermore, the validity of the accelerometers was also supported during pilot testing in the same participants, with an almost perfect correlation ($r = 0.98$) observed between accelerometer training load and running speed during treadmill-based incremental running (8–16 $\text{km}\cdot\text{h}^{-1}$).

Statistical Analyses

An a priori analysis using G*Power software (version 3.1.7; Heinrich Heine University Düsseldorf, Düsseldorf, Germany) for bivariate correlation models (using a 2-tailed alpha value of 0.05, an effect size of 0.5, and power of 0.80) recommended a sample size of 29, supporting the present analyses ($n = 44$) (6,17). Shapiro-Wilk tests indicated that the present data were suitable for parametric analyses. Relationships between internal and external training load models were determined using Pearson's product-moment correlation with 95% confidence intervals. Correlation magnitudes were evaluated according the following criteria: trivial: 0–0.10; small: 0.11–0.3; moderate: 0.31–0.50; large: 0.51–0.70; very large: 0.71–0.90; and almost perfect: 0.91–1.00 (21). The coefficient of determination (R^2) was determined to identify the commonality between each comparison made for the included internal and external training load models. Means (±*SD*) were calculated for all descriptive and outcome measures. All statistical analyses were performed using IBM SPSS Statistics (v20.0; IBM Corporation; Armonk, NY, USA). Statistical significance was accepted at $p \le 0.05$.

RESULTS

The mean ± *SD* intensity (sRPE attained after each training session and $\%\text{HR}_{\text{max}}$) of the basketball training monitored in this study is shown in Figure 2A. The mean ± *SD* internal (sRPE, TRIMP, and SHRZ models) and external training loads of the basketball training monitored in this study are displayed in Figure 2B.

The correlations and coefficients of determination between internal and external training load models during basketball training in this investigation are shown in Figure 3. Although all relationships were statistically significant ($p \le 0.001$–0.011), correlation magnitudes varied between models. Moderate relationships were found between external training load and the sRPE and TRIMP models, whereas a large relationship was evident between external training load and the SHRZ model.

DISCUSSION

This study provides the first analysis of internal and external training load models in basketball. Significant ($p \le 0.05$) correlations were observed between internal and external training load models. Contrary to our working hypothesis and providing limited support for commonality between internal and external training load approaches in basketball, the magnitude of the relationships between internal and external models were moderate to large ($r = 0.38$–0.61) with shared variances of 14–38%. Consequently, these data indicate that common internal training load models measure largely different constructs than the accelerometer training load model.

It has been theorized that internal training load models are important for monitoring the training response in athletes and external training load models are useful for prescribing and planning training (33,34). This notion indicates that internal and external training loads are 2 separate constructs that provide unique information to team-sport coaching and conditioning professionals. Indeed, our findings ($r = 0.38$–0.61, $R^2 = 0.14$–0.38) support this viewpoint given it has been suggested that outcome measures should yield shared variances greater than 50% if they represent general constructs (4). In contrast, existing research has demonstrated internal and external training load models to possess very large relationships (11,33,34), supporting the commonality of sRPE and HR-based training load models with the accelerometer training load model in field-based team sports. Consequently, internal training load (response) has been suggested to be a product of the external training load (dose) (34). However, our findings indicate that this dose-response relationship is not as strong during basketball training compared with field-based team sports. This discrepancy might be explained by the unique sport-specific training activities undertaken by basketball players compared with other team sports. Consequently, basketball coaching and conditioning professionals should be cognizant of the type of activities used during specific training sessions when applying different training load models.

Previously, significantly ($p \le 0.05$) very large relationships between sRPE and accelerometer training loads have been observed during soccer and Australian Rules football ($r = 0.74$–0.84) (11,33,34). The authors of these studies concluded that training stimuli measured by accelerometry were strongly related to the internal responses of the athletes (11,33,34). However, we observed only a moderate relationship ($r = 0.49$) with low commonality ($R^2 = 0.24$) between sRPE and accelerometer training load during basketball training. Differences between our observations and those made previously (11,33,34) might be attributable to variations in the activity modes and movement directions between basketball and field-based team sports. Basketball players are likely to experience greater intermittent and lateral movement requirements during sport-specific training activities than field-based athletes (29,31). This notion is supported by recent time-motion studies that highlight the extensive changes in movement intensity and execution of lateral shuffling during basketball activity compared with field-based team sports (10,12,29). Greater intermittent and lateral activity have been shown to exacerbate player sRPE by 13–25% when total external load is controlled (13,20,35). Accordingly, the drills typically performed during basketball training may disproportionately increase player perceptual demands relative to whole-body movements. Similarly, the distinctive movement requirements incorporated into basketball training might also account for the weaker relationships between HR-based and accelerometer training loads observed in our work compared with past findings.

To date, comparisons between HR-based and accelerometer training load models have only been provided during soccer training (11,33). Significantly ($p \leq 0.05$) very large relationships have been reported between both the TRIMP and SHRZ training load models and accelerometer training load in professional Australian ($r = 0.73–0.80$) (33) and semiprofessional Spanish ($r = 0.72$) (11) soccer players. In opposition, we observed the TRIMP and SHRZ training load models to possess moderate ($r = 0.38$, $R^2 = 0.14$) and large ($r = 0.61$, $R^2 = 0.38$) relationships with accelerometer training load, respectively. Differences between our observations and those made previously might be because of the frequent execution of isometric actions commonly performed during basketball training drills. Previously, isometric muscular contractions have been shown to elevate HR response more so than dynamic muscular contractions (28). Given basketball players frequently perform isometric actions during training activities, such as screening, blocking, defending, and positioning (26), HR responses are likely to increase disproportionately compared with the relatively low whole-body displacement that occurs in these instances. Furthermore, limitations associated with the use of HR measurement during basketball-specific activities might also have contributed to the strength of the relationships we observed between the HR-based internal training load models and accelerometer training load. Specifically, HR responses underestimate workload at supramaximal intensities and lag behind rapid changes in exercise intensity, both of which are frequently performed during basketball training (1).

Further to the intermittent activity, lateral movements, and isometric actions performed during basketball training, the quantity of directional changes is also a likely influential factor in the relationships we observed between internal and external training load models. The higher intermittent requirements combined with the smaller playing area of basketball (28 × 15 m) compared with soccer (90–120 × 45–90 m) and Australian Rules football (135–185 × 110–155 m) (10,12,29) suggest that basketball activity is likely to place a greater demand on changing direction and multidirectional running than field-based team sports (31). Such activity has been demonstrated to impose greater HR and oxygen uptake responses than linear running patterns (35). Consequently, many basketball-specific drills attempt to replicate rapid directional changes in the training environment, including those monitored in this study. The inclusion of directional changes during intermittent drills has been shown to increase the perceptual and cardiovascular responses of team-sport athletes (13). More frequent directional changes introduced to intermittent exercise have been shown to evoke larger increases in player sRPE and HR responses than traditional in-line intermittent exercise (13). Furthermore, accelerometer training load has been suggested to largely depend on accelerations in the craniocaudal movement plane, which are repetitively accentuated during each heel strike in the typical running gait (33). Given the change of direction tasks carry increased contribution of rotational and horizontal accelerations (32), these altered gait dynamics might elicit unconventional accelerometer outputs relative to the internal responses of players, compared with drills that involve large quantities of in-line running commonly performed in other team sports. Further research should examine the contribution of each movement plane to overall accelerometer training load in conjunction with internal measures during basketball training drills to confirm this suggestion.

In the completion of this study, a number of future research directions were identified. First, further research should investigate the relationships between internal and external training load models in national/international-level professional players during multiple training phases as the training schedules, activities, and thus demands are likely to vary between competition levels and across different training modes used across the annual training plan (25,29). Second, future work should examine the intraplayer relationships between internal and external training load models to more precisely monitor longitudinal patterns relative to player fitness and role (3,22). Third, the weaker correlations between internal and external training load models in our study compared with field-based team sports suggest that refinements to the accelerometer training load model in basketball might prove useful. For instance, innovations that identify and account for basketball-specific movements (e.g., multidirectional running, shuffling, isometric exertion) that carry increased cardiovascular demands and oxygen uptake (35) might better reflect the external training stimulus imposed on players. Fourth, the reliability of the sRPE model should be determined during basketball-specific training activities. Finally, although it is auxiliary to our research question, future studies should assess the validity of accelerometry to measure external training load during basketball training through comparisons with other external techniques (e.g., time-motion video analyses).

Our results demonstrated significant ($p \leq 0.05$) moderate to large ($r = 0.38–0.61$, $R^2 = 0.14–0.38$) relationships between internal and external training load models during basketball training. These data reaffirm that internal and external training load are separate constructs and indicate factors (e.g., training status, fatigue stage, and genetics) outside of the whole-body movements detected by accelerometry influence the internal response of players during basketball training.

PRACTICAL APPLICATIONS

Our results suggest that sRPE and HR-based training load models possess less commonality with accelerometer training load during basketball training than field-based team sports. Consequently, based on the present findings, basketball coaching and conditioning professionals are recommended to (a) not implement training load models based solely on the known practices and existing research findings for field-based team sports; (b) understand the unique information that each training load approach provides before implementation; (c) not assume a linear dose-response between the external training load (detected by accelerometry) and the player's internal training load during basketball-specific activities; and (d) combine the use of internal and external approaches when monitoring training load in players.

Because of the limitations associated with other technologies (time-motion video analyses and GPS technologies), the accelerometer training load model is currently the most practical approach available to monitor external training load in court-based team sports. However, if using accelerometry to monitor external training load, basketball coaching and conditioning professionals should concurrently gather sRPE and HR measurements for an indication of individualized training response, coping abilities, and progression in their athletes. Using internal and external training load models together might decrease the appearance of overtraining in athletes, thus resulting in more efficient use of practice time and improved on-court performance.

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