RELATIONSHIP BETWEEN SUBJECTIVE AND OBJECTIVE INDICATORS OF TRAINING LOAD IN DIVISION 1 MALE SOCCER PLAYERS DURING TRAINING SESSIONS AND COMPETITIVE MATCHES

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INTRODUCTION: Quantifying training and match workloads is an essential part to optimizing soccer athlete performance (Malone et al., 2015). Sport scientists and coaches use this information to evaluate compliance between planned and prescribed training, prescribe future training, and prescribe time for recovery. During games, professional and Division I men's soccer players perform over 1000 changes of direction and cover distances of 8-13km (Reilly, 2003; Stølen, Chamari, Castagna, & Wisløff, 2005). Likewise, training generally consists of small-sided games in which athletes intermittently perform frequent accelerations and changes of direction while reacting to both player and ball movement. One of the most common methods of monitoring soccer athletes is session rating of perceived exertion (sRPE) (Foster, 1998). Athletes rate the session on a scale of 1-10. This rating is then multiplied by the duration of the session to calculate the total load for the session. Apart from sRPE, time-motion analysis via GPS units and video analysis is considered the most appropriate way of monitoring soccer players (Reilly, 2003). In the literature, time-motion characteristics and sRPE are often referred to as external load and internal load, respectively (Impellizzeri, Rampinini, Coutts, Sassi, & Marcora, 2004). Few studies examine the relationship between these monitoring tools. Therefore, the purpose of this paper is to examine the relationships between sRPE and several external load metrics.

METHODS: The study involved retrospective analysis of archived monitoring data from an NCAA Division I men's soccer team. Data were collected as a normal part of the team's monitoring program during the fall competitive season. To ensure player familiarization with monitoring procedures was not an issue, only data from the last 11 games and 11 training sessions were used for analysis. The season consisted of a total of 61 training sessions and 20 games. Twelve athletes (mean±SD: age 20.4 ± 1.3 yr, weight 75.6 ± 7.2 kg, height 178.7 ± 6.2 cm) participated in all 22 sessions, resulting in a total of 264 individual observations.

Prior to each session, the athletes were equipped with a combined GPS-accelerometer unit (MinimaxX S4, Catapult Sports, Soresby, Victoria, Australia) that was positioned posteriorly between their shoulder blades per the manufacturer's directions. Each drill or period of play was manually set via software commands. Following each training session, the raw GPS files were downloaded and processed for coaching reports. The variables of interest included total distance, high-intensity running distance (HODO), and player load. High-intensity running distance was defined as distance traveled above 14.4 $km \cdot hr^{-1}$ (Bradley et al., 2009). Player load is a vector quantity developed by the manufacturer and is expressed in arbitrary units (AU). To calculate player load, the square root of the sum of the squared instantaneous rates of change in the three planes of motion is taken:

$$\text{Player load} = \sqrt{\left((aca_{t=i+1} - aca_{t=1})^2 + (act_{t=i+1} - act_{t=1})^2 + (acv_{t=i+1} - acv_{t=1})^2\right)} \Big/ 100 \quad (1)$$

where *aca* is the acceleration in the anteroposterior axis, *act* is the acceleration in the transverse axis, and *acv* is the acceleration in the vertical axis (Casamichana, Castellano, Calleja-Gonzalez, San Román, & Castagna, 2013).

Session RPE was recorded after each session when a sport scientists asked them "how do you rate this session?". While Foster et al. recommends a 30-minute time period before the recording of sRPE, subject availability did not always allow for this methodology. There is some evidence that this time period has little effect on RPE selection (Uchida et al., 2014).

Association between variables was assessed using Pearson correlation coefficients. The magnitude of the relationships were described as trivial ($r < 0.1$), small ($0.1< r <0.3$), moderate ($0.3 < r <0.5$), large ($0.5 < r <0.7$), very large ($0.7 < r <0.9$), and nearly perfect ($r > 0.9$) (Hopkins, 2002). Statistical analysis was performed using SPSS 22.0 for Windows, with significance being set at $p \leq 0.05$.

RESULTS: Values, expressed as means and standard deviations, for sRPE, total distance, HODO, and Player Load during games were 891 ± 418, 10660 ± 3848m, 6013 ± 2401m, and 1058 ± 379, respectively. Values, expressed as means and standard deviations, for sRPE, Total Distance, HODO, and Player Load during training were 187 ± 102, 3404 ± 1353m, 1564 ± 855m, and 363 ± 145, respectively. Session RPE displayed large to very large correlations to the external metrics, with weaker relationships being observed during match play. Correlations between player load, total distance, and HODO remained similar between game and training conditions. The magnitudes of the relationships are presented below in Table 1.

Table 1: Correlations between sRPE and external load metrics in games and training

Session	Relationship	Correlation
Training	sRPE-Total Distance	0.826**
	sRPE-HODO	0.786**
	sRPE-Player Load	0.802**
	Total Distance-Player Load	0.962**
	Total Distance-HODO	0.973**
	HODO-Player Load	0.945**
Games	sRPE-Total Distance	0.570**
	sRPE-HODO	0.553**
	sRPE-Player Load	0.529**
	Total Distance-Player Load	0.969**
	Total Distance-HODO	0.959**
	HODO-Player Load	0.970**

**, significant a $p < 0.01$

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DISCUSSION: The purpose of this study was to examine the relationships between subjective and objective indicators of training load. Similar to previous findings by Impellizzeri (2004) and Casamichana (2013), sRPE displayed large to nearly perfect correlations with the external load metrics included in this study. The current results provide support for the notion that both sRPE, and external load measures are both good indicators of training load experienced by the athletes, as previous research has identified sRPE as a global indicator of training load (Foster, 1998; Foster et al., 2001).

A novel finding from the present study was that the relationship between sRPE and external training load was reduced during games. This could be due to external or internal factors such as dehydration (Edwards et al., 2007) or whether the team was winning (Di Salvo, Gregson, Atkinson, Tordoff, & Drust, 2009). Furthermore, the current calculation of internal load (sRPE x Duration) may overestimate the load experienced by athletes who only played part of the match. Future research should examine alternate methods of sRPE calculation for games such as minutes played.

PRACTICAL APPLICATIONS: The current results suggest both internal and external measures of training load are useful in quantifying the total load experienced by soccer athletes. Practitioners should be careful in using these measures interchangeably, however, as the current findings show the relationships between internal and external measures of load begin to deteriorate during games. All in all, when GPS equipment is not available, sRPE seems to be a worthwhile indicator of global training load.

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