Original research

Reliability of internal and external load parameters in 6 a-side and 7 a-side recreational football for health

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Abstract

Sedentariness and related chronic disorders have a massive impact on healthcare costs worldwide. Contrariwise to endurance based activities, there are little information and evidence on recreational football amongst middle-aged healthy males. The aim of this study was to assess the reliability of internal and external load parameters during 6 a-side and 7 a-side recreational football formats. 20 subjects were enrolled (mean ± SDs; age = 37 ± 5 years, weight = 77 ± 12 kg, height = 175 ± 10 cm). Participants completed a match (55 minutes) and replicated the same match (55 minutes) a week later. The football matches took place on an artificial grass outdoor field (pitch size of 40 x 25 meters). The analysis performed using GPS considered several internal and external load parameters: heart rate (HR), total distance (TD), high speed running (HSR), number of accelerations (>2 $m \cdot s^{-2}$), and metabolic power (MT). We found good scores of reliability in several parameters in both 6 and 7 a-side, respectively: mean HR (ICC = 0.66 and 0.76), TD (ICC = 0.82 and 0.68, respectively), accelerations (ICC = 0.65 and 0.69, respectively), MT (ICC = 0.76 and 0.83), HSR (ICC = 0.79 and 0.78), HMD (ICC = 0.80 and 0.78). This study revealed good/excellent scores of absolute reliability, a small mean of change, and small/trivial effect size for internal and external load parameters during the replication analysis of the football formats. Therefore, this study showed that 6 a-side and 7 a-side are reliable recreational football formats (inter-day reliability). This new evidence can be utilised in the design of football protocols for health.

Keywords: GPS technology; team sports; soccer; futsal

Introduction

Sedentariness and related chronic disorders have a massive impact on healthcare costs worldwide [1]. Several evidences have reported that sport based activities could offer wellbeing and fitness improvements [1, 2]. Football is a team sport characterised by an intermittent model where aerobic and anaerobic components are taxed,[3] therefore football can be proposed as a source of aerobic training [4]. Several studies have already reported the potential long-term term health and physiological benefits of such recreational activity also with a different numerical format [2, 5]. In detail, various studies have reported that football is an effective physical activity for inducing cardiovascular benefits, and when performed 2 or 3 times a week, it can induces lowering blood pressure, heart rate (HR) at rest, fat percentage, low-density lipoprotein (LDL) cholesterol, and increases lean body mass, as well as maximal aerobic power (VO2max) [2, 5, 6]. Moreover, a recent evidence has shown that such activity can offers health improvement (e.g. increment of VO2max and decrement of blood pressure) in middle aged people also when performed once a week for a duration of 12 weeks [4].

Usually, recreational football is organised in smaller groups (e.g. 5 a-side, 6 a-side, 7 a-side) and played on a smaller pitch than traditional football [7–10]. Previous studies examined the effect of number manipulation during 7vs7, 3vs3 and 1vs1, finding similar HR but differences in the activity profile [8, 11, 12] Large attention was reported on these types of manipulation involving professional and amateurs football players,[13] but less attention was done on recreational football players that practice such sport for health purposes. It is known that football is an acyclic and unpredictable activity and every match has different load demands if compared to the others [14]. This is particularly true at the recreational level, where performance motivation are missing, as well as the role of the coach, and his/her encouragement are absent, therefore physiological responses necessary to have health benefit could be different, unreliable and lower than supposed [6, 11, 12, 15]. The knowledge of the recreational football workload by a deeper understanding of internal and external load parameters (e.g. total distance covered (TD), the number of changes of direction, high-speed running distance (HSR), impacts, etc.) could offer several advantages about its planning for health purposes [16]. Moreover, considering the football unpredictability (factors reported above), information about external and internal load reliability is paramount [17].

Global Positioning Systems (GPS) is a technology largely spread in the professional world [18, 19]. GPS offer the possibility to evaluate accelerations, decelerations and power activities that have critical importance in this sport. Runs including change of directions are related to higher energy cost than straight running,[20] higher energy expenditure are associated with higher health benefits,[21] therefore these parameters have a critical importance in football when proposed as health activity. Several evidences have supported the validity and reliability of such technology, in particular when new units using high acquisition frequency have been utilised, for example GPS 10-15 Hz provides a more valid and reliable measure of the athlete's movement demands compared to less sophisticated devices (1-5 Hz) [22]. However, also the validity and reliability of the most recent units decrease when testes in small distance tracks (sports specific circuits), high intensity change of directions (e.g. short shuttle runs), and during high-speed movements (e.g. peak speed) [23, 24]. Some metrics such as TD are high reliable, while others, such as accelerations and decelerations reported lower score of reliability [25]. Therefore, sports scientist are evaluated [26].

Despite the importance of this topic, considering the problematic associated with sedentariness in the current modern society, no one has investigated the reliability of internal and external load parameters in middle-aged males during 6 and 7 a-side recreational health formats. The aim of this study is to assess by GPS the reliability of workload parameters (i.e. HR, TD, accelerations and decelerations, etc.) during recreational 6 and 7 a-side games. An important research question might be: are the internal and external load variables reliable during recreational football matches (inter-day reliability)? [17]

Methods

Subjects

20 male subjects without specific pathologies were enrolled in this study during 2016-17 (mean ± SDs; age = 37 ± 5 years, weight = 77 ± 12 kg, height = 175 ± 10 cm). All participants were informed about the potential risks of the study and signed an informed consent in agreement with University of Suffolk (Ipswich, UK) politics. All procedures were conducted according to the declaration of Helsinki for human studies of the World Medical Association.

Experimental protocol and data analysis

The football matches (6 and 7 a-side) took place on an artificial grass outdoor field (pitch size of 40 x 25 meters). Participants completed 4 recreational football matches of 55 minutes each, and every participant took part at 2 trials. Intra-day reliability was evaluated using the same protocol adopted in literature by the same research group [4, 15, 17]. Training load parameters were recorded by means of 10 Hz GPS system (STATSports, Ireland). Heart rate was recorded during matches using Polar RS400D heart rate monitor watches (Polar, Oulu, Finland). HR and GPS data were analysed with Viper Software 1.2. Validity of this GPS system has been verified in previously conducted research [15]. The analysis considered several internal and external load parameters: mean HR, TD measured in metres, HSR over 14.4 $km \cdot h^{-1}$, number of accelerations and decelerations performed (>2 $m \cdot s^{-2}$), relative velocity calculated as the ratio between TD and the total time. In addition, GPS recorded data about metabolic power measured in $w \cdot kg^{-1}$ and high intensity metabolic power distance over 20 $w \cdot kg^{-1}$ (HMD) [27]. Ecological validity of metabolic power in football was previously reported [28]. The integration of triaxial accelerometers into GPS devices offers additional information about athletes' physical loads calculated in arbitrary units (AU). Dynamic body load (DBL) was evaluated by a triaxial accelerometer (100-Hz), which summates accelerations in the 3 movement axes (X, Y, and Z planes) to measure a composite magnitude vector (expressed as a Gforce). DBL is a specific indicator of mechanical stress, and it show a good relationship with external (TD, $r = 0.70$) and internal (rating of perceived exertion, $r = 0.74$) load variables [29].

Statistical analysis

Statistical analysis was performed using SPSS (SPSS Statistics 20.0) for Mac OS X Yosemite. A Shapiro-Wilk test was performed for the evaluation of normality (assumption) for statistical distribution. Log transformation was done for non-normal data. Paired t-test was performed between Match 1 and Match 2 for each variable to identify systematic change. Data are presented as means ± SD. Statistical significance was set at $p < 0.05$. Absolute reliability of HR data was assessed using the typical error (TE) of measurement and interclass correlation (ICC) [30]. ICC interpretation is expressed: poor < 0.4, fair > 0.4, good > 0.6, excellent > 0.75 [31]. Load evaluation differences between were reported as a mean of change with confidence intervals (CI 90%) [30]. The Cohen's d (ES) was calculated to determine the magnitude of effect by standardizing the coefficients according to the appropriate between-subjects standard deviation. Furthermore, the Cohen's d (ES) was assessed using the following criteria: trivial < 0.2, small > 0.2, medium > 0.5, large > 0.8 [32].

Results

Data recorded during 6 a-side matches (match and its replication) were (means ± 1 SD): mean HR = 160.4 ± 8.9 bpm and 158.6 ± 10.5 bpm respectively, $p > 0.05$, ES = 0.18 (trivial), TD 4715 ± 552 m and 4673 ± 448 m respectively, $p > 0.05$, ES = 0.08 (trivial), accelerations number 33 ± 16 and 36 ± 14.7 respectively, $p > 0.05$, ES = 0.19 (trivial), decelerations number 30 ± 17 and 32 ± 16 respectively, $p > 0.05$, ES = 0.12 (trivial), MP 7.9 ± 1.2 $w \cdot kg^{-1}$ and 7.9 ± 0.9 $w \cdot kg^{-1}$

respectively, $p > 0.05$, ES = 0 (trivial), relative velocity 85.7 ± 10 m·min^{-1} and 85.0 ± 8.9 m·min^{-1} respectively, $p > 0.05$, ES = 0.07 (trivial), HSR 375 ± 213 m and 406 ± 195 m respectively, $p > 0.05$, ES = 0.15 (trivial), HMD 533.9 ± 202.8 m and 596.3 ± 169.5 m respectively, $p > 0.05$, ES = 0.33 (small), DBL 88.7 ± 45.4 AU and 111.2 ± 49.1 AU respectively, $p > 0.05$, ES = 0.47 (small).

Data recorded during 7 a-side matches (match and its replication) were (means ± 1 SD): mean HR = 157.9 ± 9.5 bpm and 156.1 ± 11.2 bpm respectively, $p > 0.05$, ES = 0.17 (trivial), TD 4438 ± 609 m and 4672 ± 523 m, $p > 0.05$, respectively ES = 0.41 (small), accelerations number 34.5 ± 14.6 and 33.2 ± 13.5 respectively, $p > 0.05$, ES = 0.09 (trivial), decelerations number 34.6 ± 13.2 and 33.8 ± 11.9 respectively, $p > 0.05$, ES = 0.06 (trivial), MP 7.6 ± 1.0 w·kg^{-1} and 7.7 ± 1.8 w·kg^{-1} respectively, $p > 0.05$, ES = 0.15 (trivial), relative velocity 80.6 ± 11.1 m·min^{-1} and 85.1 ± 9.5 m·min^{-1} respectively, $p > 0.05$, ES = 0.43 (small), HSR 340.2 ± 194.2 m and 364.1 ± 148.4 m respectively, $p > 0.05$, ES = 0.13 (trivial), HMD 572.4 ± 203.1 m and 573.6 ± 173.8 m respectively, $p > 0.05$, ES = 0.001 (trivial), DBL 118 ± 55.6 AU and 116 ± 54.2 AU respectively, $p > 0.05$, ES = 0.03 (trivial). Reliability of the internal and external load parameters were reported as TE, ICC and mean of change with CI 90%, and presented in table 1 and table 2.

Discussion

To our knowledge, this is the first study to provide internal and external workload information, and their reliability, during 6 a-side and 7 a-side recreational football matches in middle-aged males. We found good/excellent values of reliability (ICC), a small/trivial ES, and small mean of change for internal and external load parameters between the first match and its replication (see table 1 and 2) for both 6 a-side and 7 a-side formats. The findings show that the two recreational football formats have high consistency in the workload produced, and therefore this study offers additional evidence to the suitability of recreational football as a health activity [2, 6, 33]. The information reported in this study can be used by sports scientists to better manage the football sessions to achieve their aims. By the manipulation of the game formats, it could be possible to offer the correct physiological stimuli able to increase health parameters in middle-aged male subjects.

Contrariwise to running based exercise where workload parameters can be easily manipulated, and where participants can reach exactly the goals of the training session (e.g. mean HR and TD) [1], in recreational football this is not possible because several factors can influence the workload variables [17]. Football is an unpredictable activity where Physical fitness, technical and tactical skills factors can affect the performance [10, 34], and every game has different load demands if compared to the others [14]. Running demands are influenced by several contextual factors (e.g. possession status, players level, etc.) [35, 36]. For instance, previous studies reported that high-intensity activity (>19.8 km/h) has high variability with a CV equivalent to 18.1% [37]. Physiological responses necessary to have health benefit could be lower than expected, and unreliable (among the matches) [6, 11, 15]. Contrariwise, this study supported the reliability of both internal and external load parameters during both the formats. These new evidences agree with a recent study that found excellent reliability score for mean HR (ICC = 0.82) and TD (ICC = 0.66) during football 5-a side formats in middle aged participants [17]. Recreational players commonly reduce the size of the pitch and the number of players since it is easier to arrange smaller groups for friendly matches [4, 7–9]. Two previous publications have evaluated the effect of players number manipulation during 7vs7, 3vs3 and 1vs1 [12], finding similar mean HR, but differences in the activity profile, and during 7vs7, 5vs5 and 3vs3 [11], finding similar peak HR, and blood lactate responses. In recreational football formats, generally, internal load parameters seem quite stable (HR in 3vs3, 5vs5, and 7vs7 equivalent to 159, 159 and 157 bpm, respectively), contrariwise, external load variables (e.g. accelerations) present more variability when players and pitch size are manipulated [11]. The current study underlines the reliability of such recreational health training formats. In detail were found good/excellent reliability score for mean HR (ICC = 0.66 and 0.76) during 6 a-side and 7 a-side respectively), as well as, for several external load parameters during both 6 a-side and 7 a-side such as: TD (ICC = 0.82 and 0.68, respectively), accelerations (ICC = 0.65 and 0.69, respectively), MP (ICC = 0.76 and 0.83), HSR (ICC = 0.79 and 0.78), HMD (ICC = 0.80 and 0.78). This information is particularly useful because it showed that football can replicate the same stimuli (internal and external) match after match. A recent publication has analysed the reliability of some 6 a-side SSGs involving professional and amateur players and it has reported a high score of reliability for several external load parameters: TD (ICC = 0.84), accelerations (ICC = 0.74), MP (ICC = 0.78), HSR (0.74) and high MP > 20 w·kg (ICC = 0.75) [38]. The results reported in the current study closely mirror the results reported in such study showing almost the same scores.

The evaluation of external load parameters can guarantee a better understanding of the request of recreational football. The correct quantification of accelerations, decelerations, HSR, and DBL offer practical advantages during the periodisation of this health activity, moreover, such information could be paramount to rightly manipulate the game formats and develop specific physiological stimuli. Another interesting result is associated with the high number of accelerations and decelerations recorded in this study in both 6 a-side and 7 a-side formats. Shuttle runs and power actions affect the total energy expenditure of the activity [20], and previous studies reported that the energy cost of runs with the change of direction (e.g. 180°) can be several (from 3 to 7) times higher than during linear running [20].

The main limitation of this study is associated with the technology used to recording the workload variables. GPS underestimate the external load parameters during short shuttle runs [19, 39], and generally, the literature reports that all GPS brands have some limitations when accelerations and power actions are recorded [16, 40]. Reliability of accelerations and decelerations during 6 a-side (ICC values of 0.65 and 0.69, respectively) and 7 a-side (ICC values of 0.65 and 0.72, respectively) have been reported in this study. Considering the limitations of GPS technology reported above, researchers and sport scientists should be conscious of the potential bias of such analysis (accelerations and decelerations).

Future studies could adopt brand new technologies that could offer higher accuracy than the GPS units utilised in this study. Future studies could also evaluate if GPS can play an important role in injury prevention in recreational football [41, 42]. Moreover, future researchers could also take into considerations the limitations of recreational football such as the risk/benefit ratio. This argument is particularly interesting because small evidence has been reported about football contraindications (e.g. injuries) while a large body of studies has been shown its physiological benefits. Considering the high intensity of football and its characteristics (invasion sport), it is possible to suppose a higher injury risk compared to jogging and running-based activities [4, 9].

Conclusions

This study reports that both internal and external load parameters have a good/excellent grade of reliability during football 6 and 7 a-side game formats. This new evidence supports the utilisation of football as a health activity. This study offers innovative evidence on external load variables missing in literature (e.g. accelerations, decelerations and power activities). The correct management of load parameters as well as game formats and rules could specify ways to manipulate the physiological stimuli able to increase health parameters in middle-aged male subjects. In conclusion, the new information presented by this research give several practical applications in the designing of recreational football protocols.

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Table 1. Reliability of internal and external load parameters during football 6 a-side.

Variables	Mean of change (CI 90%)	Typical Error (CI 90%)	ICC (CI 90%)
Mean HR (bpm)	-1.5	7.1	0.66
	(-4.7; 1.6)	(25.8; 9.13)	(0.41; 0.83)
TD (m)	-41.9	228	0.82
	(-166; 83.4)	(181; 313)	(0.65; 0.89)
Accelerations (n°)	3.3	9.5	0.65
	(-1.8; 5.9)	(7.2; 11.1)	(0.57; 0.82)
Decelerations (n°)	2.1	10.9	0.62
	(-3.9; 8.2)	(8.7; 14.9)	(0.59; 0.78)
MP (w kg^{-1})	-0.05	0.56	0.76
	(-0.35; 0.26)	(0.44; 0.76)	(0.55; 0.88)
RV (m·min^{-1})	-0.76	4.15	0.82
	(-3.01; 1.51)	(3.3; 5.69)	(0.65; 0.92)
HSR (m)	30.8	69.9	0.79
	(-7.2; 69.1)	(55.4; 95.6)	(0.69; 0.85)
HMD (m)	62.4	87.5	0.80
	(14.5; 110.2)	(68.5; 119.3)	(0.61; 0.90)
DBL (AU)	22.5	32.3	0.55
	(4.8; 40.2)	(25.6; 44.3)	(0.23; 0.77)

ICC = Interclass Correlation, CI = Confidence Intervals, TD = Total Distance, MP = Metabolic power, RV = Relative Velocity, HSR = High Speed Running over 14.4 km h^{-1}, HMD = High Intensity Metabolic Power Distance over 20 w kg^{-1}, DBL = Dynamic Body Load, AU = Arbitrary Units.

Table 2. Reliability of internal and external load parameters during football 7 a-side.

Variables	Mean of change (CI 90%)	Typical Error (CI 90%)	ICC (CI 90%)
Mean HR (bpm)	-1.84	5.2	0.76
	(-4.11; 0.43)	(4.3; 6.6)	(0.60; 0.86)
TD (m)	238.9	374	0.68
	(14; 462)	(291; 530)	(0.43; 0.84)
Accelerations (n°)	-1.3	4.6	0.69
	(-4.1; 1.4)	(3.6; 6.5)	(0.57; 0.75)
Decelerations (n°)	-0.8	3.86	0.75
	(-3.1; 5.5)	(3.0; 5.5)	(0.65; 0.81)
MP ($w·kg^{-1}$)	0.1	0.39	0.83
	(-0.13; 0.33)	(0.30; 0.55)	(0.65; 0.92)
RV ($m·min^{-1}$)	4.3	6.8	0.59
	(0.27; 8.4)	(5.3; 9.6)	(0.25; 0.80)
HSR (m)	23.9	64.4	0.78
	(-25.8; 73.7)	(47.5; 102.6)	(0.60; 0.85)
HMD (m)	1.23	67.5	0.78
	(-35.7; 38.2)	(53.6; 92.6)	(0.67; 0.84)
DBL (AU)	-2.5	14.5	0.64
	(-11.6; 6.51)	(11.3; 20.9)	(0.56; 0.67)

ICC = Interclass Correlation, CI = Confidence Intervals, TD = Total Distance, MP = Metabolic power, RV = Relative Velocity, HSR = High Speed Running over 14.4 km h^{-1}, HMD = High Intensity Metabolic Power Distance over 20 w kg^{-1}, DBL = Dynamic Body Load, AU = Arbitrary Units.