

Individualized speed threshold to analyze the game running demands in soccer players using GPS technology

Umbral de velocidad individualizado para analizar en jugadores de fútbol mediante tecnología GPS las exigencias de sus desplazamientos en competición

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Abstract. The aim of the study was to compare the relative running demands ($\text{m}\cdot\text{min}^{-1}$), among different soccer players positions, coded by an absolute threshold vs. an individualized threshold based on splits of 10% of peak velocity, during friendly games, with the same tactical system and monitoring with a GPS. To this end he had 20 players on a semiprofessional soccer team. All players were monitored with a unit GPS (15 hz SPI-pro W2b, GPSport, Canberra, Australia). They are measured peak velocity with a sprint of 40 m, and its activity in 4 friendly matches. The player's activities were coded into five absolute speed thresholds and ten individualized speed thresholds. The absolute speed thresholds were: Very low intensity running (VLIR: $0\text{--}7\text{ km}\cdot\text{h}^{-1}$), Low intensity running (LIR: $7\text{--}13\text{ km}\cdot\text{h}^{-1}$), medium intensity running (MIR: $13\text{--}18\text{ km}\cdot\text{h}^{-1}$), high intensity running (HIR: $18\text{--}21\text{ km}\cdot\text{h}^{-1}$), and very high intensity running (VHIR: $>21\text{ km}\cdot\text{h}^{-1}$). The individualized thresholds were from $<10\%$, $10\text{--}20\%$, $20\text{--}30\%$, $30\text{--}40\%$, $40\text{--}50\%$, $50\text{--}60\%$, $60\text{--}70\%$, $70\text{--}80\%$, $80\text{--}90\%$, and $>90\%$ of peak velocity (PV). Variables are presented as the mean (\pm SD), and the estimated precision is indicated with 90% confidence limits (CL). In addition to the analyses for statistical significance (i.e., paired t-tests), possible differences between players' position was analysed (pairwise comparisons) for practical significance using magnitude-based inferences. The 30% of players get 80-90% of its peak velocity in match and 2.5% reaches 90-100% of its peak velocity.

Key words: Peak velocity, threshold speed, soccer.

Resumen. El objetivo del estudio fue analizar las demandas de carrera en jugadores de fútbol con diferentes roles empleando tecnología GPS, analizando y comparando sus desplazamientos durante partidos amistosos en base a un umbral absoluto, frente a un umbral individualizado al perfil locomotor del jugador. Para ello se les valoró su pico máximo de velocidad realizando un sprint de 40 m, así como su actividad locomotora en 4 partidos amistosos. Los desplazamientos de los jugadores se codificaron en cinco umbrales de velocidad absolutos y diez umbrales de velocidad individualizados. Los umbrales de velocidad absolutos fueron: carrera de muy baja intensidad (VLIR: $0\text{--}7\text{ km}\cdot\text{h}^{-1}$), carrera de baja intensidad (LIR: $7\text{--}13\text{ km}\cdot\text{h}^{-1}$), carrera de intensidad media (MIR: $13\text{--}18\text{ km}\cdot\text{h}^{-1}$), carrera de alta intensidad (HIR: $18\text{--}21\text{ km}\cdot\text{h}^{-1}$), y carrera de muy alta intensidad (VHIR: $>21\text{ km}\cdot\text{h}^{-1}$). Los umbrales individualizados en base a su pico de velocidad máxima (PV) fueron: $<10\%$, $10\text{--}20\%$, $20\text{--}30\%$, $30\text{--}40\%$, $40\text{--}50\%$, $50\text{--}60\%$, $60\text{--}70\%$, $70\text{--}80\%$, $80\text{--}90\%$, and $>90\%$ del PV. El 30% de los jugadores consiguen el 80-90% de su pico de velocidad en partidos y el 2.5 % alcanza el 90-100 % de su pico de velocidad.

Palabras claves: Pico de velocidad, umbrales de velocidad, fútbol.

Introduction

Soccer is a tactical game, therefore the players behavior on the field is often constrained by tactical tasks (Mendez-Villanueva, Buchheit, Simpson, Peltola, & Bourdon, 2011; Buchheit, Simpson, & Mendez-Villanueva, 2013). Recently, the global position systems (GPS) have been used to describe the physical profile of the soccer player during the tactical tasks resolution in friendly (Casamichana, Castellano, & Castagna, 2012; Dwyer, & Gabbett, 2012; Buchheit, Allen, Poon, Mondonutti, Gregson, & Di Salvo, 2014; Varley, Gabbett, & Aughey, 2014; Mallo, Mena, Nevado, & Paredes, 2015) and in official games (Suarez-Arrones, Torreno, Requena, Saez de Villarreal, Casamichana, Barbero-Alvarez, et al., 2015). Coaches and researchers using GPS indicate that the locomotor profile can be different as a result of the age (Buchheit, Mendez-Villanueva, Simpson, & Bourdon, 2010), playing position (Suarez et al., 2015; Mallo et al., 2015; Buchheit et al., 2010, 2013; Mendez-Villanueva et al., 2012), or the fatigue development during the match (Randers, Mujika, Hewitt, Santisteban, Bischoff, Solano, et al., 2010; Lovell, Barrett, Portas, & Weston, 2013).

The activity profile is categorizing in different speed zones ranging from 0 to $36\text{ km}\cdot\text{h}^{-1}$ and no standardized speed zones are observed (Cummins, Orr, O'Connor, & West, 2013). Delaserra, Gao, & Ransdell (2014) report that lack of a universal definition leads to confusion over the threshold levels speed, and can lead to false conclusions that are made based on where the speed threshold is fixed. Usually the players' activities are coded in five absolute speed thresholds: Walking ($0\text{--}7\text{ km}\cdot\text{h}^{-1}$), running at low speed ($7\text{--}13\text{ km}\cdot\text{h}^{-1}$), at medium speed ($13\text{--}18\text{ km}\cdot\text{h}^{-1}$), at high speed ($18\text{--}21\text{ km}\cdot\text{h}^{-1}$), and at sprint ($>21\text{ km}\cdot\text{h}^{-1}$)

(Casamichana et al., 2012, Suarez-Arrones et al., 2015). The difference in field position and speed characteristics prevents the development of arbitrary sprint zone classification (Waldrom, Highton, Worsolf, & Daniels, 2011). The studies have not provided a justification for their use of an absolute speed threshold, therefore could have a potential error in the measurement of player activity and generating the need for individualized the speed threshold (Abt & Lovell, 2009). An individual threshold have used for determining sprint activities of young soccer players using a 61% of 10-m split of 40-m sprint (Buchheit, Mendez-Villanueva, Simpson, & Bourdon, 2010, 2013; Mendez-Villanueva, Buchheit, Simpson, Peltola, & Bourdon, 2013), flying 10 m sprint time (Harley, Barnes, Portas, Lovell, Barrett, Paul, et al., 2010), and the distance run at high-intensity running using VT2 (Abt & Lovell, 2009). Recently, Sparks, Coetzee, & Gabbett, (2016) have reported an analysis of university-level soccer players with GPS technology using an individual threshold to categorize his running demands during a match. These authors, following to Dwyer, & Gabbett, (2012), showed that the low, moderate and high intensity velocity zone are $<34\%$, between 34% and 61%, and $>61\%$ of players' maximum velocity in 30-40 m split of 40m sprint test, respectively, and compared the time spent in these individualized intensity zones with the time spent in different internal loads zone (heart rate, HR) during matches (Sparks et al., 2016). Until now, no study has reported on the physical profile of adult soccer player with GPS technology, using an individual threshold to categorize his running demands during a match, and differentiating the relative running demands by playing position

The aim of the study was to compare the running demands among different soccer players' positions, coded by an absolute threshold vs. an individualized threshold based on splits of 10% of peak velocity, during friendly games, with the same tactical system and monitoring with a GPS technology.

Methods

Participants

Time-motion analysis activity was collected from 20 semiprofessional soccer players of Spanish soccer league (age 26.6±4.1 years; height 178.5±5.8 cm.; body mass 74.4±5.6 kg.). The players were assigned to 1 of 5 positional groups: Full Backs (FB, n=4), Central Backs (CB, n=4), Central Midfielders (CM, n=4), Wide Midfielder (WM, n=4), and Forwards (F, n=4) (Mallo et al., 2015). All players participated on average 14 hours combining soccer-specific training and 1-2 strength training sessions per week. Data were obtained from routine monitoring of work-rate in friendly games during the preseason with opponents of the same level. Therefore, usual appropriate ethics committee was not required clearance (Winter & Maughan, 2009). Team and players confidentiality were granted and the study followed the Code of Ethics of the World Medical Association (Declaration of Helsinki). The University Human Research Ethics Committee granted the ethics approval for all of the experimental procedures.

Activity Pattern Measurements

Players were required to wear a GPS unit (15 hz SPI-pro W2b, GPSport, Canberra, Australia) fitted to the upper back of each player using a neoprene harness, during sprint test and in four matches. The number of satellites for GPS was satisfactory during sprint test and all matches: ranged 4-11, average 7.8±2. GPS data were analyzed with Team AMS-R1-2012.9 software. The use GPS technology for monitoring a match play provides a reliable and valid measure of the physical profile of the players (Coutts & Duffield, 2010; Varley, Fairweather &, Aughey, 2012), and peak velocity (Buchheit, Haddad, Simpson, Palazzi, Bourdon, Di Salvo, & Mendez-Villanueva, 2014).

Experimental Procedures

All players undertook a 40 m maximal running speed to determine his peak velocity (PV). This test was performed outdoor natural grass field. Players wore soccer boots during the test. Players commenced the sprint from a standing start with their front foot 0.5 m behind the start line and were instructed to sprint as fast as possible over the 40 m distance (Mendez-Villanueva et al., 2011). The test was preceded by standardized 20 min warm-up, consisting in 5 min of mobility, stretches in active tension, 7 min of jogging, 2 running progressions of 40 m, and a maximum acceleration of 10 m. Each subject performed 2 trials separated by at least 3 min of rest, the highest GPS peak velocity was recorded.

Match analyses were performed 4 times in all players during a total of 4 friendly matches played over a period of four weeks. All matches were played on the same 100 x 70 m outdoor natural grass field, which no dismissal occurred. Tactically, all players used 4-4-2 system.

Match running demands analysis

The relative total distance covered (RTD, m·min⁻¹) of all players who participated in entire first half were collected (Cummins et al.,

2013). Player's activities were coded into five absolute speed thresholds and ten individualized speed thresholds. The absolute speed thresholds were: Very low intensity running (VLIR: 0-7 km·h⁻¹), Low intensity running (LIR: 7-13 km·h⁻¹), medium intensity running (MIR: 13-18 km·h⁻¹), high intensity running (HIR: 18-21 km·h⁻¹), and very high intensity running (VHIR: >21 km·h⁻¹) (Casamichana, et al., 2012; Suarez-Arrones, et al., 2015). The individualized thresholds were from <10%, 10-20 %, 20-30%, 30-40%, 40-50%, 50-60%, 60-70%, 70-80%, 80-90%, and >90% of peak velocity (PV).

Statistical Analysis

Variables are presented as the mean (± SD), and the estimated precision is indicated with 90% confidence limits (CL). In addition to the analyses for statistical significance (i.e., paired t-tests), possible differences between players' position was analysed (pairwise comparisons) for practical significance using magnitude-based inferences (Hopkins, 2006). The data were log-transformed prior to the analysis to reduce non-uniformity of error. The standardised differences or effect sizes (90% confidence interval) between the scores and interval times were calculated. The threshold values for the Cohen effect size (ES) statistics were: trivial (0.0–0.19), small (0.2–0.59), moderate (0.6–1.1), large (1.2–1.9) and very large (>2.0) (Batterham & Hopkins, 2006; Hopkins, Marshall, Batterham, & Hanin, 2009). Probabilities were also calculated to establish whether the true (unknown) differences were lower, similar or higher than the smallest worthwhile difference (0.2 multiplied by the between-subject standard deviation, based on Cohen's effect size principle). The quantitative chances of higher or lower differences were evaluated qualitatively as follows: <1%, almost certainly not; <5%, very unlikely; <25%, unlikely/probably not; 25–75%, possibly/possibly not; >75%, likely/probably; >95%, very likely; >99%, almost certainly (Batterham & Hopkins, 2006; Hopkins et al. 2009). A substantial effect was established as >75 %. If the likelihood of higher or lower differences was >75%, the true difference was assessed as clear (substantial) (Aughey, 2011; Jennings, Cormack, Coutts, & Aughey, 2012).

Results

PV, RTD, and RTD covered into five absolute speed thresholds and ten individualized speed thresholds are present for each playing position in Table 1. Mean RTD and PV were 104.5±11.8 m·min⁻¹ and 31.6±1.4 km·h⁻¹ respectively. The soccer players normally used between 0-80% of their PV during the match. Only 30% of the players reached 80-90% of their PV and only 2.5% got to get values > 90% of their PV. Playing position, absolute and individual threshold have impacted substantially on distance covered. CM showed a PV substantially lower PV than all groups, but there were no substantial differences with respect to FB (Very large ES for CB and WM; moderate ES for F). FB showed a substantially lower peak velocity than CB and WM (moderate ES). CM and WM covered a substantially higher RTD than all groups, but there were no substantial differences with respect to F (all moderate

Table 1. Match running profile in semiprofessional soccer players (only first half). Data are mean ± SD.

Variables	CB (n=16)	FB (n=16)	CM (n=16)	WM (n=16)	F (n=16)
PV (km·h ⁻¹)	31.43±0.56 ^b	30.43±1.18	29.45±1.15 ^{ab}	31.45±0.87 ^b	32.50±2.40
RTD (m·min ⁻¹)	98.99±6.25 ^{bc}	102.93±7.26 ^{cd}	109.56±16.46 ^{ab}	109.15±11.22 ^{ab}	104.89±12.91
Absolute Threshold (m·min⁻¹)					
VLIR 0-7 km·h ⁻¹	38.46±5 ^{bc}	41.49±3.67	39.21±4.49 ^{bc}	38±5.33 ^{bc}	41.4±1.47
LIR 7-13 km·h ⁻¹	39.53±5.54	38.74±4.48	45.05±7.91 ^{abc}	40.95±8.81 ^c	36.46±7.11
MIR 13-18 km·h ⁻¹	14.90±4.10	15.60±3.44	19.69±6.46 ^{ab}	20.26±4.42 ^{abc}	17.42±5.04 ^d
HIR 18-21 km·h ⁻¹	3.46±1.30	3.96±1.22	3.62±2.06	5.54±1.95 ^{abc}	4.98±0.68 ^{abc}
VHIR>21 km·h ⁻¹	2.64±1.31	3.14±1.34	1.89±1.54 ^{ab}	4.40±2.45 ^{abc}	4.63±1.08 ^{abc}
Individual Threshold (m·min⁻¹)					
<10% PV	5.05±0.51 ^{cd}	4.53±0.53	3.83±0.74 ^{cd}	4.39±0.65	4.89±0.71 ^{bcd}
10-20% PV	30.65±3.48	32.69±2.16a	31.39±3.47	31.30±4.01	33.39±1.44 ^{cd}
20-30% PV	20.14±3.35	21.31±2.44 ^{cd}	19.61±3.53	20.1±3.64	19.11±3.05
30-40% PV	20.01±3.26	20.25±3.11	25.75±5.37 ^{abc}	21.84±4.92	20.24±4.48
40-50% PV	13.6±2.6	13.51±2.93	18.18±4.99 ^{abc}	17.28±3.26 ^{abc}	13.71±3.81
50-60% PV	7.05±2.45	7.5±1.7	8.8±3.27 ^{ab}	9.99±2.62 ^{abc}	8.89±2.53 ^{ab}
60-70% PV	1.09±0.75 ^b	1.51±0.72	0.99±0.76 ^b	2.02±0.94 ^{abc}	2.27±0.17 ^{abc}
70-80% PV	(12.5%)1.37±0.79	1.35±0.71	(18.7%)0.99±0.62 ^{abd}	1.84±1.35 ^b	2.11±0.82 ^{abc}
80-90% PV	(25%)0.28±0.25	(31.2%)0.41±0.31	(62.5%)0.27±0.19	(25%)0.55±0.56 ^{bc}	(25%)0.38±0.17
>90% PV	(100%)0.0±0.0	(100%)0.0±0.0	(100%)0.0±0.0	(100%)0.0±0.0	(100%)0.0±0.0

a. Substantial difference with CB; b. Substantial difference with FB; c. Substantial difference with CM; d. Substantial difference with W; e. Substantial difference with F; (%) Percentage of players who do not reach this velocity during the matches. RTD relative total distance, PV peak velocity, VLIR very low intensity running, LIR low intensity running, MIR medium intensity running, HIR high intensity running, and VHIR very high intensity running.

ES but CM vs. FB small ES). CB covered a substantially lower RTD than all groups.

WM and F covered a substantially higher relative distance than all groups $>18 \text{ km}\cdot\text{h}^{-1}$ (large and moderate ES). Also among the values 60-70% of their PV the difference in relative distance was substantially higher than the other groups (very large, large and moderate ES). At the threshold of 70-80% of their PV, only the Fs obtained substantial differences with respect to other groups (large and moderate ES). The 12.5% CB and 18.7% CM did not achieve a PV of 70-80%.

CM and WM covered a substantially higher relative distance between 13 and $18 \text{ km}\cdot\text{h}^{-1}$ (moderate ES, but WM vs. F small ES, and CM vs. F trivial ES) and between 40-50% PV (moderate ES), between 50-60% S covered a substantially higher relative distance than others groups too (moderate ES).

CM covered a substantially higher relative distance between 7 and $13 \text{ km}\cdot\text{h}^{-1}$ (Moderate ES, but CM vs. W small ES) and between 30-40% PV (Large and moderate ES).

FB and F covered a substantially higher distance $< 7 \text{ km}\cdot\text{h}^{-1}$ (Moderate ES, but FB vs. CM small ES), but FB have covered a higher distance (Moderate ES, but FB vs. CM small ES, and FB vs. WM, CB trivial ES). CB and F covered a higher distance than all groups between 0-10% (Large and moderate ES, but F vs. FB small ES).

Discussion

The aim of the present study was to compare the relative demands of races between different soccer players' positions, coded by an absolute threshold vs. an individualized threshold based on 10% maximum speed intervals, during friendly matches, with the same system Tactical and monitored with GPS technology. The main findings of the present study were: a) An individualized threshold based on player's peak velocity offers running demands among different playing positions with a specific tactical system (4-4-2), slightly more specifics than absolute threshold, at very high, high, medium and very low intensity running, b) F covered the highest distance between 60-80% PV and between $>10\%$, with substantial differences respect all groups between 70-80% PV, c) WM covered the highest distance between 50-70% PV, e) CM has covered the highest distance between 30-50% PV, f) FB and CD covered the lowest distance between 70-80% PV and between 30-60% PV.

RTD in the present study ($104 \text{ m}\cdot\text{min}^{-1}$) was similar than $104 \text{ m}\cdot\text{min}^{-1}$ obtained by Varley et al., (2014) during friendly matches, lower than $119 \text{ m}\cdot\text{min}^{-1}$ obtained by Suarez-Arrones et al., (2015) in official games, and lower than 119 & $113 \text{ m}\cdot\text{min}^{-1}$ obtained by Mallo et al., (2015) and Casamichana et al., (2012), respectively, in friendly matches. The absolute threshold showed similar distribution than others studies where WM and CM have covered the highest relative distance and CB has covered the lowest relative distance during a match (Mallo et al., 2015; Suarez et al., 2015;).

A recent systematic review showed that the majority of research concentrate upon the distance covered at high-intensity efforts (Cummins et al., 2013), and several authors assert that high intensity run is seen as the best measure (Abt & Lovel 2009). In our study, the RTD covered $>18 \text{ km}\cdot\text{h}^{-1}$ is similar that the obtained in friendly matches (Varley et al., 2014) and lower than obtained in official games (Suarez-Arrones, et al., 2015). Suarez-Arrones et al., (2015), affirm that WM and second striker covered a higher distance than all groups between $18-21 \text{ km}\cdot\text{h}^{-1}$, and only WM has covered a higher distance than others $>21 \text{ km}\cdot\text{h}^{-1}$. Our results showed that with using an absolute threshold WM and F have covered a higher RTD than all groups $>18 \text{ km}\cdot\text{h}^{-1}$. But when we use an individual threshold, WM and F have covered a highest distance between 60-70% PV, while is F cover a higher distance between 70-80%, but without substantial differences with WM. We can explain this difference with Suarez-Arrones et al., (2015), because are used different tactical roles (4-4-1-1 vs. 4-4-2). The tactical role space for our F in 4-4-2 is similar than second striker in 4-4-1-1. The tactical role space for our WM is more reduced than for a wide-midfielder (4-4-1-1),

and their participation is exclusively in offensive phase of the game, while wide-midfielders have an equal responsibility in offensive and defensive phase. This tactical have produced that in our system WM cover a similar distance than F and in 4-4-1-1 wide-midfielder has covered a higher distance than all groups $> 21 \text{ km}\cdot\text{h}^{-1}$. Mallo et al., (2015) and Suarez-Arrones et al., (2015) showed that CB obtained the lowest values of distance covered at high-speed. We obtained similar result when we used individual threshold 60-70% PV, but there was no difference with CM. No found substantial different between CB and FB with absolute threshold and between 70-80% PV. These results showed that only individual threshold obtained different physical performance $>18 \text{ km}\cdot\text{h}^{-1}$ among different soccer players positions. The tactical role of WM and F have a high running demands around 60-70% PV, but only F have a very high running demands around 70-80%, that the absolute threshold $>18 \text{ km}\cdot\text{h}^{-1}$ cannot discriminate, for these players and this tactical system.

The absolute threshold between $13-18 \text{ km}\cdot\text{h}^{-1}$ is similar a range between 40-60% PV. The running demands with absolute threshold showed that CM and WM covered a higher distance than all groups. According with this, results CM and WM covered a higher distance than all groups between 40-60% PV too. Contrary in part with our results, Suarez-Arrones et al., (2015) shows that the second striker has covered a substantially higher distance that all groups at these velocities, and Mallo et al., (2015) shows that CM has covered a higher distance than FB and CD. In our results F covered a higher distance than other groups when distance covered was obtained with individual threshold (50-60% PV). These results showed that absolute and individual threshold no discriminate physical performance between $13-18 \text{ km}\cdot\text{h}^{-1}$ in the same way among different soccer players' positions. In this interval, the tactical role of CM have high running demands around 40-50% PV, while WM has between 40-60%, and F has around 50-60%, that the absolute threshold $13-18 \text{ km}\cdot\text{h}^{-1}$ cannot discriminate, for these players and this tactical system.

Low intensity running is determined by an absolute threshold between $7-13 \text{ km}\cdot\text{h}^{-1}$ and between 30-40% PV. Our results show that CM covers a higher distance than all groups without differences between absolute and individual threshold. According in part with our results, Suarez et al., (2015) showed that CM has covered the highest distance but they no found differences between central midfielder, wide-midfielder and second striker at these velocities. However, Mallo et al., obtained differences between CM and FB and F. An absolute threshold between $0-7 \text{ km}\cdot\text{h}^{-1}$ and between $>30\%$ PV determines very low intensity running. Others studies show that full back, central midfielder and wide-midfielder have covered a lower distance than all groups (Suarez-Arrones et al., 2015). Nevertheless our results show that FB, and F have covered a higher distance than other groups $< 7 \text{ km}\cdot\text{h}^{-1}$. FB has covered a higher distance than all groups at 20-30% PV, and CB and F at $>10\%$ PV. Accordingly, this individualized threshold no will provide an absolute differentiation of low and very low intensity running.

The findings presented here are limited by the data were collected from a friendly matches and from all players who participated in entire first half. Due to the impossibility of using the GPS during official matches, at the time of measurement, forced us to take the data of friendly matches. These friendly matches are played to a greater extent in the preseason period. During the preseason, in the second half of the match, there are many player changes, so the analysis of only the first half allows us to register the player during all the minutes played and under the same conditions.

We are according with Buchheit et al., (2013, p.40) when affirm «Game tactical and strategic requirements are likely to modulate on-field players' activity patterns independently (at least partially) of players' physical capacities», but we have to know the players' activity patterns in a tactical system and the physical capacities of the players who play in the different positions of this tactical system for planning properly his training. The use of absolute speed threshold with irrespective of physical capacities of the players is used to compare the absolute running demands of a/an game/games in professional's players

(Mallo et al., 2015; Suarez, et al., 2015; Casamichana et al., 2010) and to assess the progression of the young players over the developing years (Buchheit et al., 2013). But the absolute threshold could underestimate or overestimate the intensity of the effort of playing position during a match. We could conclude that an individualized threshold based on peak velocity of the player offers specific demands of running among different roles of the semi-professional's players in a tactical system, reducing the error to assess physical performance of the players, and it is adapted at any physiological test, to differentiate the intensity of the effort for each player.

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