



Quantification of Respiratory and Muscular Perceived Exertions as Perceived Measures of Internal Loads During Domestic and Overseas Training Camps in Elite Futsal Players

Yu-Xian Lu^{1,2}, Filipe M. Clemente^{3,4}, Pedro Bezerra^{3,5}, Zachary J. Crowley-McHattan⁶, Shih-Chung Cheng¹, Chia-Hua Chien⁷, Cheng-Deng Kuo^{8,9,10*} and Yung-Sheng Chen^{2,7,10*}

OPEN ACCESS

Edited by:

Bruno Travassos,
University of Beira Interior, Portugal

Reviewed by:

Júlio Alejandro Costa,
Portuguese Football Federation,
Portugal
Timothy Lathlean,
Flinders University, Australia

*Correspondence:

Cheng-Deng Kuo
cdkuo23@gmail.com
Yung-Sheng Chen
yschen@utapei.edu.tw

Specialty section:

This article was submitted to
Movement Science and Sport
Psychology,
a section of the journal
Frontiers in Psychology

Received: 31 July 2021

Accepted: 15 December 2021

Published: 28 January 2022

Citation:

Lu Y-X, Clemente FM, Bezerra P, Crowley-McHattan ZJ, Cheng S-C, Chien C-H, Kuo C-D and Chen Y-S (2022) Quantification of Respiratory and Muscular Perceived Exertions as Perceived Measures of Internal Loads During Domestic and Overseas Training Camps in Elite Futsal Players. *Front. Psychol.* 12:751030. doi: 10.3389/fpsyg.2021.751030

¹ Graduate Institute of Athletics and Coaching Science, National Taiwan Sport University, Taoyuan, Taiwan, ² Department of Exercise and Health Sciences, University of Taipei, Taipei City, Taiwan, ³ Escola Superior de Desporto e Lazer, Instituto Politécnico de Viana do Castelo, Rua Escola Industrial e Comercial de Nun'Álvares, Viana do Castelo, Portugal, ⁴ Instituto de Telecomunicações, Delegação da Covilhã, Lisbon, Portugal, ⁵ Research Center in Sports Performance, Recreation, Innovation and Technology (SPRINT), Melgaço, Portugal, ⁶ Discipline of Sport and Exercise Science, Faculty of Health, Southern Cross University, Lismore, NSW, Australia, ⁷ Exercise and Health Promotion Association, New Taipei City, Taiwan, ⁸ Department of Medical Research, Taipei Veterans General Hospital, Taipei City, Taiwan, ⁹ Department of Medicine, Taian Hospital, Taipei City, Taiwan, ¹⁰ Tanyu Research Laboratory, Taipei City, Taiwan

Background: The rating of perceived exertion (RPE) scales with respiratory and muscular illustrations are recognized as simple and practical methods to understand individual psychometric characteristics in breathing and muscle exertion during exercise. However, the implementation of respiratory and muscular RPE to quantify training load in futsal training camps has not been examined. This study investigates respiratory and muscular RPE relationships during domestic training camps (DTC) and overseas training camps (OTC) in an under 20 futsal national team.

Methods: Data collected from eleven field players were used for comparison in this study (age = 18.7 ± 0.7 years, height = 171.9 ± 6.1 cm, body weight = 64.2 ± 8.4 kg). All players reported Borg CR10 RPE (RPE_{CR10}) and 7-scales respiratory RPE ($RPE_{respiration}$) and muscular RPE (RPE_{muscle}) (Dalhousie pictorial scales) after training sessions and matches. Additionally, total distance covered (TD) and training impulse (TRIMP) were used to quantify external and internal loads via the Polar Team Pro system. Paired-sample *t*-tests were used to compare the RPE_{CR10} , $RPE_{respiration}$, RPE_{muscle} , TD, and TRIMP between DTC and OTC. Furthermore, linear regression was performed to determine the relationships among all RPE scales, TD, and TRIMP.

Results: The RPE_{CR10} ($p = 0.047$), TD ($p < 0.001$), and TRIMP ($p < 0.001$) showed significant difference between DTC and OTC. Furthermore, linear regression analyses showed significant correlation between $RPE_{respiration}$ and RPE_{muscle} (DTC: $r = 0.857$, $p = 0.006$; OTC: $r = 0.924$, $p < 0.001$), RPE_{CR10} and $RPE_{respiration}$ (DTC: $r = 0.857$,

$p = 0.001$; OTC: $r = 0.863$, $p = 0.001$), and RPE_{CR10} and RPE_{muscle} (DTC: $r = 0.906$, $p < 0.001$; OTC: $r = 0.900$, $p < 0.001$).

Conclusion: Pictorial $RPE_{respiration}$ or RPE_{muscle} can be used as an alternative to quantify perceived measures of internal loads during DTC and OTC in futsal players. Interpretation of perceived measures of training load and cardiac-related responses in association with external training loads during short-term training camps would be useful in further understanding the demands of futsal players' experience in these circumstances.

Keywords: monitoring training loads, training camps, futsal training, Borg CR10, heart rate, total distance covered

INTRODUCTION

The monitoring of training loads is a practical method to evaluate physical adaptation and recovery status during a training period (Bourdon et al., 2017). Methodologies to monitor training loads can be divided into internal and external measures (Impellizzeri et al., 2019). Internal measures of load can be evaluated *via* self-report measures [i.e., rating of perceived exertion (RPE)] or objective measures of physiological response [i.e., heart rate (HR) and blood lactate concentration] (Clemente et al., 2019). Conversely, external load measures that assist in measuring locomotion profiles *via* microelectromechanical systems (e.g., global navigation satellite system, inertial measurement unit, or local positioning system) can be used to evaluate physical impact and physiological strains during training sessions and competitions (Halson, 2014).

Futsal is a high-intensity intermittent and strenuous indoor sports (Barbero-Alvarez et al., 2008) requiring both aerobic and anaerobic energy systems to maintain vigorous physical and mental conditions (Naser et al., 2017). Futsal competitions are incredibly high in intensity and often cause intensive physiological and psychological strains to the players. It has been reported that high-speed running ($18.1\text{--}25\text{ km}\cdot\text{h}^{-1}$) and sprinting ($>25\text{ km}\cdot\text{h}^{-1}$) account for 22.6% of the total distance covered (TD) during a competitive futsal match. Additionally, field players have average HR responses between 170 and 190 $\text{beats}\cdot\text{min}^{-1}$ in Liga Nacional de Futbol Sala (around 83% of maximal HR during the match time), representing a high cardiovascular load on players (Barbero-Alvarez et al., 2008). This cardiovascular load results from rapid changes in various activities every 8–9 s (e.g., high-speed running, sprints, change of direction, and lateral and backward activity) during matches (Álvarez et al., 2009).

Much like during match scenarios, monitoring the demands of futsal training is also important to understand the accumulation of the training load imposed on an individual player (Clemente et al., 2020). Among the possible methods of monitoring internal load, the RPE is a simple and practical tool to quantify since it is a valid, low-cost, and reliable method in measuring exercise intensity (Haddad et al., 2017). The RPE is based on psychological perception in response to training and/or exercise stimuli. An 11-points scale version from 0 (no exertion) to 10

(maximal effort), Borg CR10 scale (RPE_{CR10}), is developed to evaluate physiological and psychological perceptions in response to exercise strain in laboratory and field settings (Foster et al., 2001). Subsequently, the RPE_{CR10} in respect to the exercise or training duration was used to quantify internal training load in sports training (Foster et al., 2001). This method has been extensively used in team sports, such as soccer (Impellizzeri et al., 2004; Clemente et al., 2019) and futsal players (Chen et al., 2020; Clemente et al., 2020; Stochi de Oliveira and Borin, 2021) due to convenience and user-friendliness.

The respiratory ($RPE_{respiration}$) and muscular (RPE_{muscle}) perceived exertions are variants of RPE scales. The $RPE_{respiration}$ and RPE_{muscle} primarily focus on the breathing efforts and leg fatigue during exercise, respectively (Pianosi et al., 2014, 2015). The benefit of using both the $RPE_{respiration}$ and RPE_{muscle} scales is that they identify specific characteristics of psychophysiological responses in cardiopulmonary and leg muscle performance. The advantage of using different RPE scales to quantify training load is related to the sensitivity of the measurement. In terms of Dalhousie pictorial scales, seven different illustrations for dyspnea (chest tightness, throat closure, breathing effort, etc.) and perceived leg exertion (light leg, heavy leg, soft leg, etc.) are used to represent different physiological strains in responses to different exercise loads. The validity to use Dalhousie scales to rate respiratory and leg muscle exertions during exercise activity has been reported in pediatric populations, compared to RPE_{CR10} measure.

In terms of specific training sessions, physical demands may activate different sensory feedbacks and physiological constraints in target body systems during the performance. McLaren et al. (2016) previously reported that the sensitivity of $RPE_{respiration}$ was different from RPE_{muscle} during incremental cycling and treadmill running in university soccer players. Furthermore, Wright et al. (2020) recently demonstrated that young female soccer players experienced stronger perceived exertions in breathing and muscular engagement during fitness and resistance training, respectively. However, no difference in respiratory and muscular perception during soccer training sessions and matches has been observed. Wright et al.'s (2020) study implied the different perceptions of sensory sources to specific training types in this population. However, the application of these measures in futsal training lacks sufficient investigation and requires further elucidation.

Futsal training camps include team preparation, player selection, building and developing team tactics and formations, physical and mental preparation, and team squad readiness. In general, domestic training camps (DTC) provide benefits for testing squad members in individual and team performance, periodizing physical and mental preparation, and tactical strategies prior to tournaments (Clemente et al., 2020). Conversely, overseas training camps (OTC) have advantages in creating a simulative environment of official tournaments and thus familiarizing players with the usual intensity of psychophysiological responses during competitions (Lu et al., 2019; Chen et al., 2020). However, a comparative study to examine training loads between DTC and OTC has not been reported elsewhere.

In light of the above, this study compares the different training measures during DTC and OTC in under 20 (U-20) male futsal players, and examines relationships between the RPEs and traing impulse (TRIMP)/TD. It was hypothesized that there would be significant differences in measured variables between DTC and OTC. The secondary hypothesis was that the relationship between perceived exertions and TRIMP/TD would be established during DTC and OTC.

MATERIALS AND METHODS

Participants

Eleven male futsal field players from a national U-20 futsal team voluntarily participated in this study (age = 18.7 ± 0.7 years, height = 171.9 ± 6.1 cm, body weight = 64.2 ± 8.4 kg). All players signed informed consent forms and were familiarized with the procedures in reporting RPE values. This study was approved by the Human Ethics Committee of the University of Taipei (UT-IRB-2018-068) and undertaken in accordance with the Declaration of Helsinki and its later amendment.

Design and Procedure

This was a prospective cohort study to observe the training loads during futsal training camps. The training camps consisted of eight short-term DTC (including 83 training sessions, total training duration = 149.23 h) and three short-term OTC (including 14 training sessions and 11 friendly matches, total training/match duration = 41.87 h). The description of the study period and the individual exposure time to training are presented in **Tables 1, 2**, respectively. **Figure 1** illustrates the number and types of training sessions during each training camp. The training loads during the training camps were assessed *via* (1) perceived internal load = RPE_{CR10} , $RPE_{respiration}$, RPE_{muscle} ; (2) HR-related internal load = TRIMP; and (3) external load = TD. During all training sessions and friendly matches, all players wore microsensors HR monitors on the chest (Polar Team Pro, Polar Electro, Kemple, Finland). The microsensor and chest strap were marked with a unique jersey number throughout the training camps. HR responses and activity profiles were recorded and used to calculate TRIMP and TD for subsequent data processes. For the RPE

TABLE 1 | The description of study period.

Training camps	Duration (days)	Interval between the training camp (days)
DTC1	7	–
DTC2	7	44
DTC3	7	14
DTC4	7	21
DTC5	7	12
OTC1	4	8
DTC6	5	83
DTC7	6	10
DTC8	5	16
OTC2	6	9
OTC3	9	43

DTC, domestic training camps; OTC, overseas training camps.

scales, players reported individual perception of RPE_{CR10} , $RPE_{respiration}$, and RPE_{muscle} responses within 30 min after training sessions or friendly matches (Impellizzeri et al., 2004). The team sports trainer asked the players the following three questions: (1) How hard was your training session? (2) How does your breathing feel? (3) How do your legs feel? Subsequently, session RPE_{CR10} ($sRPE_{CR10}$), session $RPE_{respiration}$ ($sRPE_{respiration}$), and session RPE_{muscle} ($sRPE_{muscle}$) were used to calculate training loads. The $sRPE$ was calculated based on the RPE scales \times time of training sessions or matches (Foster et al., 2001).

Rating of Perceived Exertion

Each individual's RPE responses were recorded using the Borg CR10 scale and Dalhousie pictorial scale to quantify RPE_{CR10} , $RPE_{respiration}$, and RPE_{muscle} , respectively. The RPE_{CR10} is a brief version of 0–10 points scale, modified from the original Borg RPE (Borg, 1998). The RPE_{CR10} is a visual analog scale that is numerically represented as 0 being “not at all” and 10 being “extremely intense.” Additionally, the Dalhousie pictorial scales consisted of seven cartoon pictures to reflect perceived exertion in breathing effort and leg sensation during exercise. The lowest value of 1 represented “very light feeling” and the highest value of 7 represented “extremely intense feeling” (Pianosi et al., 2014, 2015, 2016). In our study, the 7-points Dalhousie pictorial scale was used to assess the respiratory and muscular RPE as it is correlated with respiratory and muscular exertions during exercise in adolescents (median value of Spearman's $r > 0.9$) (Pianosi et al., 2015). Subsequently, all RPE scores were multiplied by the time of training sessions and friendly matches as session RPE values (Foster et al., 2001). The participants were informed of the definition of RPE scales on the first registration day and were afforded the opportunity to practice reporting RPE values during the first DTC.

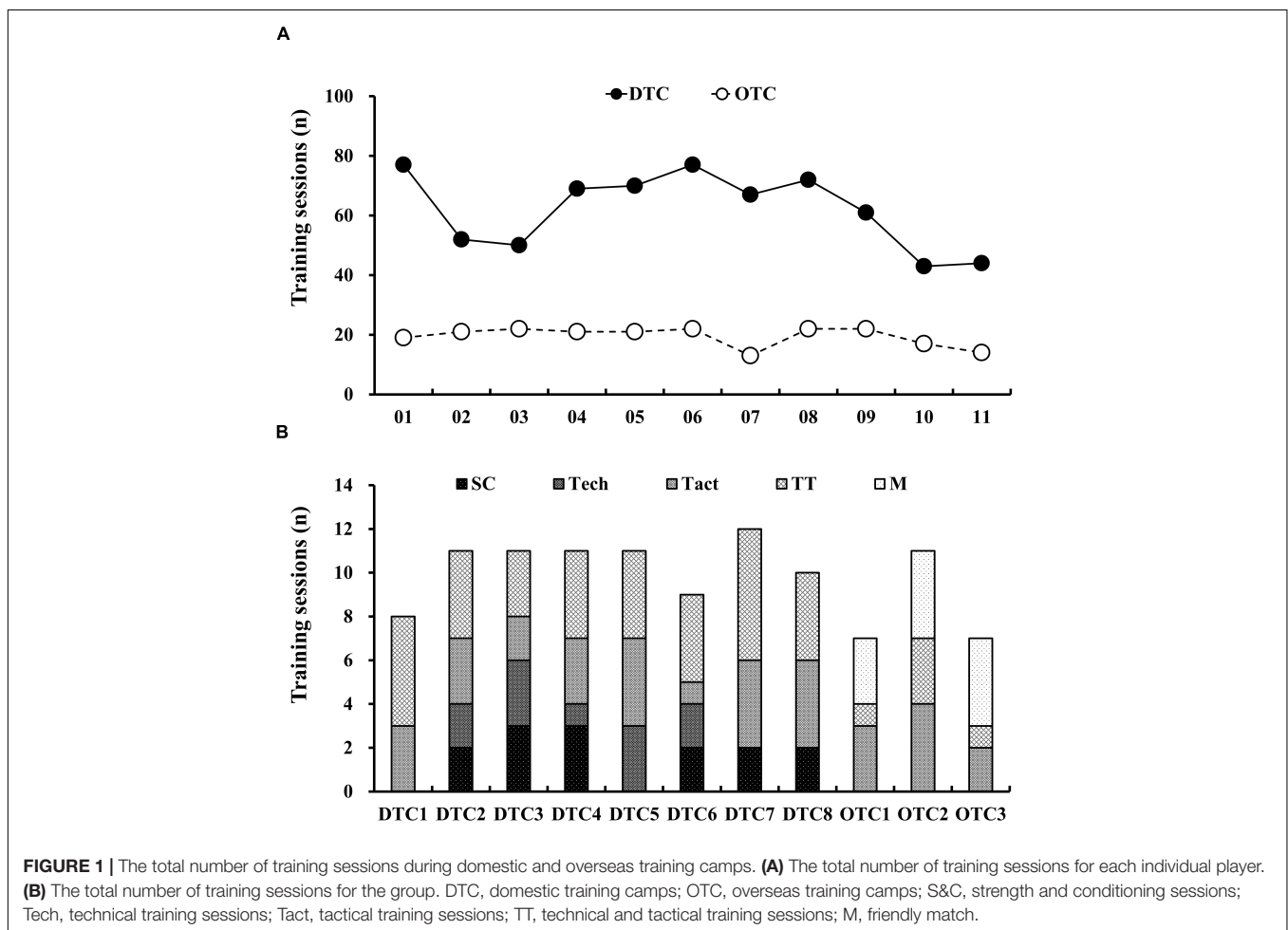
Training Impulse

Polar microsensors recorded the exercising HR responses during training and matches and were used to calculate TRIMP. The

TABLE 2 | The individual exposure time to training during the training camps.

Player	DTC1 (min)	DTC2 (min)	DTC3 (min)	DTC4 (min)	DTC5 (min)	DTC6 (min)	DTC7 (min)	DTC8 (min)	OTC1 (min)	OTC2 (min)	OTC3 (min)
01	344	1291	1204	1189	1162	951	1208	917	686	623	793
02	361	1051	1204	1189	1262	–	–	783	686	834	793
03	115	1151	–	–	1142	699	1208	783	686	856	875
04	585	1291	1204	1189	1262	262	972	783	686	749	875
05	585	1163	763	1189	1042	951	1075	783	686	856	766
06	699	1291	1204	1189	927	951	1208	783	686	844	875
07	596	1169	1204	1080	1262	541	780	783	686	702	–
08	820	1169	242	1189	1262	951	1208	783	686	834	875
09	820	933	1204	1189	689	951	1030	–	686	856	875
10	465	671	894	1080	1262	–	–	475	686	586	556
11	–	–	1204	977	–	541	1006	783	–	706	875

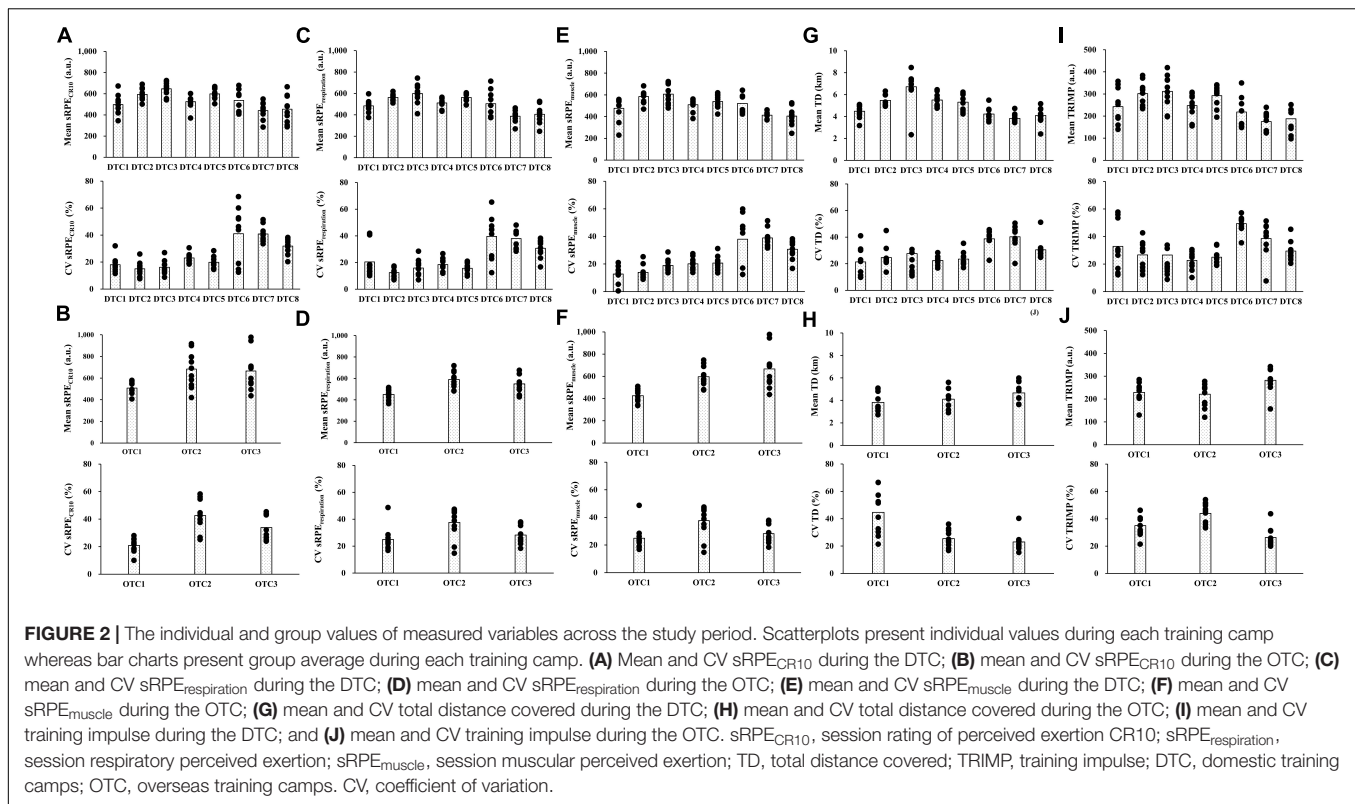
DTC, domestic training camps; OTC, overseas training camps.



Edward’s method equation was used (Edwards, 1993) following the formula:

$$\begin{aligned}
 \text{TRIMP} = & \text{Time in HR zone 1} * 1 + \text{Time in HR zone 2} * 2 \\
 & + \text{Time in HR zone 3} * 3 + \text{Time in HR zone 4} * 4 \\
 & + \text{Time in HR zone 5} * 5
 \end{aligned}
 \tag{1}$$

The HR zones were defined as 50–59% of maximal HR (HR_{max}), 60–69% of HR_{max} , 70–79% of HR_{max} , 80–89% of HR_{max} , and 90–100% of HR_{max} as HR zone 1, HR zone 2, HR zone 3, HR zone 4, and HR zone 5, respectively. The HR responses below 50% of HR_{max} were excluded in data collection. The HR_{max} was determined using individual peak HR responses during the Yo-Yo intermittent recovery level 1 test in the first DTC.



Total Distance

The TD is a sum of the traveled distance during training sessions and friendly matches. The same Polar Team Pro system (Polar Electro, Kempe, Finland) that is used for HR monitoring was used to record each player's traveled distance. Each player was mounted with a microsensor containing a 3-dimensional accelerometer, a gyroscope, and a digital compass that sampled at a rate of 200 Hz.

Statistical Analyses

The descriptive data were presented as means \pm standard deviations (SD). Furthermore, the coefficient of variation (CV) was calculated for group or individual variability across the training camps. The average values of means and CV during a single training camp were used for statistical analyses. The normality of study variables was examined with the Kolmogorov–Smirnov test. Paired *t*-tests were used to compare the group average value of measured variables between DTC and OTC (data points: DTC = 682 data vs. OTC = 214 data). Standard differences of variables were examined by using Cohen's *d* effect size (ES). The standardized differences of the ES were interpreted as trivial (0.0–0.2), small (0.2–0.6), moderate (0.6–1.2), large (1.2–2.0), or very large (>2.0) (Hopkins et al., 2009). Linear regression analysis was used to examine the relationship among (1) sRPE_{CR10}, sRPE_{respiration}, and sRPE_{muscle}; and (2) between perceived exertions (sRPE_{CR10}, sRPE_{respiration}, and sRPE_{muscle}) and TRIMP/TD training loads. Significant differences between the means were set as $p < 0.05$. All statistical analyses were

performed by SPSS version 25.0 software for Windows (IBM Corp, Armonk, NY, United States).

RESULTS

Comparisons Between Domestic and Overseas Training Camps

Individual and group values of TD, TRIMP, sRPE_{CR10}, sRPE_{respiration}, and sRPE_{muscle} during DTC and OTC training camps are presented in **Figure 2**.

For the pairwise comparisons between DTC and OTC, the result showed that TD [$t = 13.592$, $p < 0.001$, ES = 2.79 (very large)] and TRIMP [$t = 7.357$, $p < 0.001$, ES = 1.12 (moderate)] during DTC were significantly higher than that of OTC. All RPE scales demonstrated higher absolute values. However, only sRPE_{CR10} [$t = -2.260$, $p = 0.047$, ES = -0.80 (moderate)] and sRPE_{CR10} [$t = 2.352$, $p = 0.041$, ES = -0.88 (moderate)] had significant differences (**Table 3**).

Linear Regressions of Rating of Perceived Exertions, Total Covering Distance, and Training Impulse

Figure 3 presents the linear regression among the sRPE_{CR10}, sRPE_{respiration}, and sRPE_{muscle}. The sRPE_{CR10} demonstrated a good positive association to sRPE_{respiration} during DTC ($r = 0.857$, $p = 0.001$) and OTC ($r = 0.863$, $p = 0.001$). The sRPE_{CR10} demonstrated excellent positive association to

TABLE 3 | The perceived exertion of CR10, respiratory and muscular scales, training impulse, and total covering distance during the domestic and overseas training camps.

	Domestic camps		Overseas camps		Difference	<i>p</i> -Value	Effect size (90% CI)	QI for effect magnitude (mean difference; $\pm 90\%$ CI)
	Mean \pm SD	CV (%)	Mean \pm SD	CV (%)				
RPE _{CR10} (a.u.)	4.92 \pm 0.55	11.23	5.56 \pm 0.94	16.97	-0.64	0.047	-0.80 (-1.55 - -0.09); moderate	Very likely (1.2/3.3/95.5)
RPE _{respiration} (a.u.)	4.58 \pm 0.36	7.90	4.79 \pm 0.48	10.08	-0.21	0.183	-0.48 (-1.20 - 0.22); small	Likely (4.2/14.0/81.8)
RPE _{muscle} (a.u.)	4.67 \pm 0.30	6.4	5.05 \pm 0.78	15.53	-0.39	0.156	-0.62 (-1.36 - 0.09); moderate	Likely (5.3/5.9/88.8)
sRPE _{CR10} (a.u.)	532.73 \pm 60.81	11.42	615.01 \pm 112.63	18.31	-82.27	0.041	-0.88 (-1.64 - -0.16); moderate	Very likely (1.1/2.5/96.3)
sRPE _{respiration} (a.u.)	494.83 \pm 44.33	8.96	528.37 \pm 56.53	10.70	-33.54	0.115	-0.64 (-1.37 - 0.07); moderate	Likely (2.7/8.9/88.4)
sRPE _{muscle} (a.u.)	504.37 \pm 40.84	8.10	559.76 \pm 91.05	16.27	-55.38	0.094	-0.76 (-1.51 - -0.05); moderate	Likely (3.0/4.3/92.7)
TRIMP (a.u.)	410.21 \pm 82.71	20.16	319.64 \pm 73.33	22.94	90.56	<0.001	1.12 (0.38 - 1.91); large	Most likely (99.8/0.2/0)
TD (km)	8.44 \pm 0.79	9.35	5.61 \pm 1.13	20.07	2.833	<0.001	2.79 (1.85 - 3.91); very large	Most likely (99.9/0/0)

RPE_{CR10}, rating of perceived exertion CR10; RPE_{respiration}, respiratory perceived exertion; RPE_{muscle}, muscular perceived exertion; sRPE_{CR10}, session RPE_{CR10}; sRPE_{respiration}, session RPE_{respiration}; sRPE_{muscle}, session RPE_{muscle}; SD, standard deviation; QI, qualitative inferences; CV, coefficient of variation; CI, confidence interval; TRIMP, training impulse; TD, total distance covered.

sRPE_{muscle} during DTC ($r = 0.906$, $p < 0.001$) and OTC ($r = 0.900$, $p < 0.001$). Additionally, the sRPE_{respiration} demonstrated good positive association to sRPE_{muscle} during DTC ($r = 0.763$, $p = 0.006$) and OTC ($r = 0.924$, $p < 0.001$).

In **Figure 4**, the sRPE_{CR10}, sRPE_{respiration}, and sRPE_{muscle} demonstrated poor positive association to TD during DTC (sRPE_{CR10}: $r = 0.090$, $p = 0.792$; sRPE_{respiration}: $r = 0.008$, $p = 0.980$; sRPE_{muscle}: $r = 0.238$, $p = 0.480$) and OTC (sRPE_{CR10}: $r = 0.065$, $p = 0.849$; sRPE_{respiration}: $r = 0.092$, $p = 0.789$; sRPE_{muscle}: $r = 0.008$, $p = 0.982$).

In **Figure 5**, the sRPE_{CR10}, sRPE_{respiration}, and sRPE_{muscle} demonstrated poor positive association to TRIMP during DTC (sRPE_{CR10}: $r = 0.135$, $p = 0.692$; sRPE_{respiration}: $r = 0.144$, $p = 0.672$; RPE_{muscle}: $r = 0.031$, $p = 0.928$). But OTC (sRPE_{CR10}: $r = 0.586$, $p = 0.058$; sRPE_{respiration}: $r = 0.469$, $p = 0.145$; sRPE_{muscle}: $r = 0.574$, $p = 0.065$) had higher positive association than DTC.

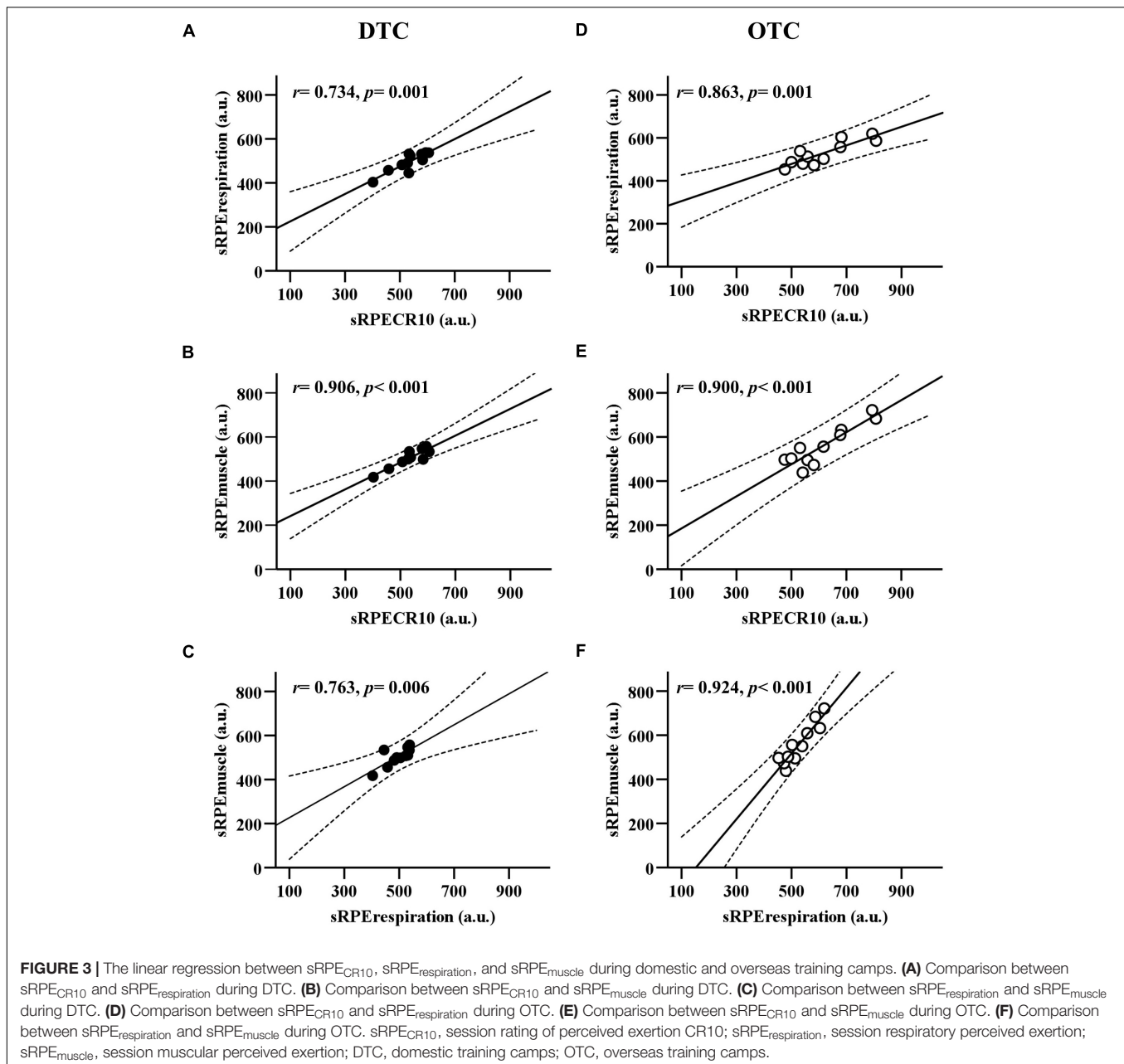
DISCUSSION

This study is the first to quantify training loads using RPE_{respiration} and RPE_{muscle} during DTC and OTC in male futsal players. The primary findings revealed that DTC demonstrated larger TD and TRIMP than that of OTC. Whereas RPE_{CR10} was significantly larger during OTC than that of DTC, no significant differences in RPE_{respiration} and RPE_{muscle} were observed between DTC and OTC. The second finding in this study was that RPE_{respiration} and RPE_{muscle} demonstrated a positive linear association to RPE_{CR10}. Thus, either RPE_{respiration} or RPE_{muscle} can be used to quantify internal load during DTC and OTC in futsal players. Additionally, individual variability of measuring variables varied from camp to camp. Three different RPE scales showed similar dispersion and tendency of individual and group values across the DTC. Finally, TD and TRIMP are independent markers to training loads quantified by RPE scales during short-term futsal training camps.

We found that mean values of TD and TRIMP were significantly larger during DTC than that of OTC. It seems that there is a large demand of physical engagement during futsal DTC. Conversely, the RPE_{respiration} and RPE_{muscle} demonstrated no difference between the two different types of training camps. These findings highlighted the discrepancy of subjective and objective assessments of training loads in futsal DTC and OTC. Conversely, the different activity profiles that experienced between DTC (generally focused on fitness development, player selection, and technical evaluation) and OTC (usually incorporates more friendly matches and fewer training sessions to prepare for competition) could be a factor to explain these findings (Chen et al., 2020). Another possible explanation for these findings could be greater intersubject variability of RPE measures. Nevertheless, it is challenging to compare our observations with other populations, levels of players, or sports due to limited studies reporting internal or external loads during OTC.

It is interesting to note that the RPE_{CR10} was significantly larger during OTC than that of DTC. Although larger values of RPE_{respiration} and RPE_{muscle} were observed during OTC, the results did not approach statistical significance. Indeed, the RPE_{CR10} is a self-report tool to reflect the overall engagement of psychophysiological efforts during the training or match. The higher values of RPE_{CR10} and sRPE_{CR10} reported during OTC might be related to a high frequency of friendly matches. Futsal is a high-intensity intermittent sports (Spyrou et al., 2020) with characteristics of quick decision-making on top of highly demanding technical and tactical performance (Corrêa et al., 2016). It seems that the players experienced higher perceptive loads rather than physiological strains during OTC as evidenced by TRIMP and TD metrics. However, the psychological stress and mental effort were not evaluated in this study. Thus, the overall contribution of psychological aspects on the intensity of RPE level is unknown.

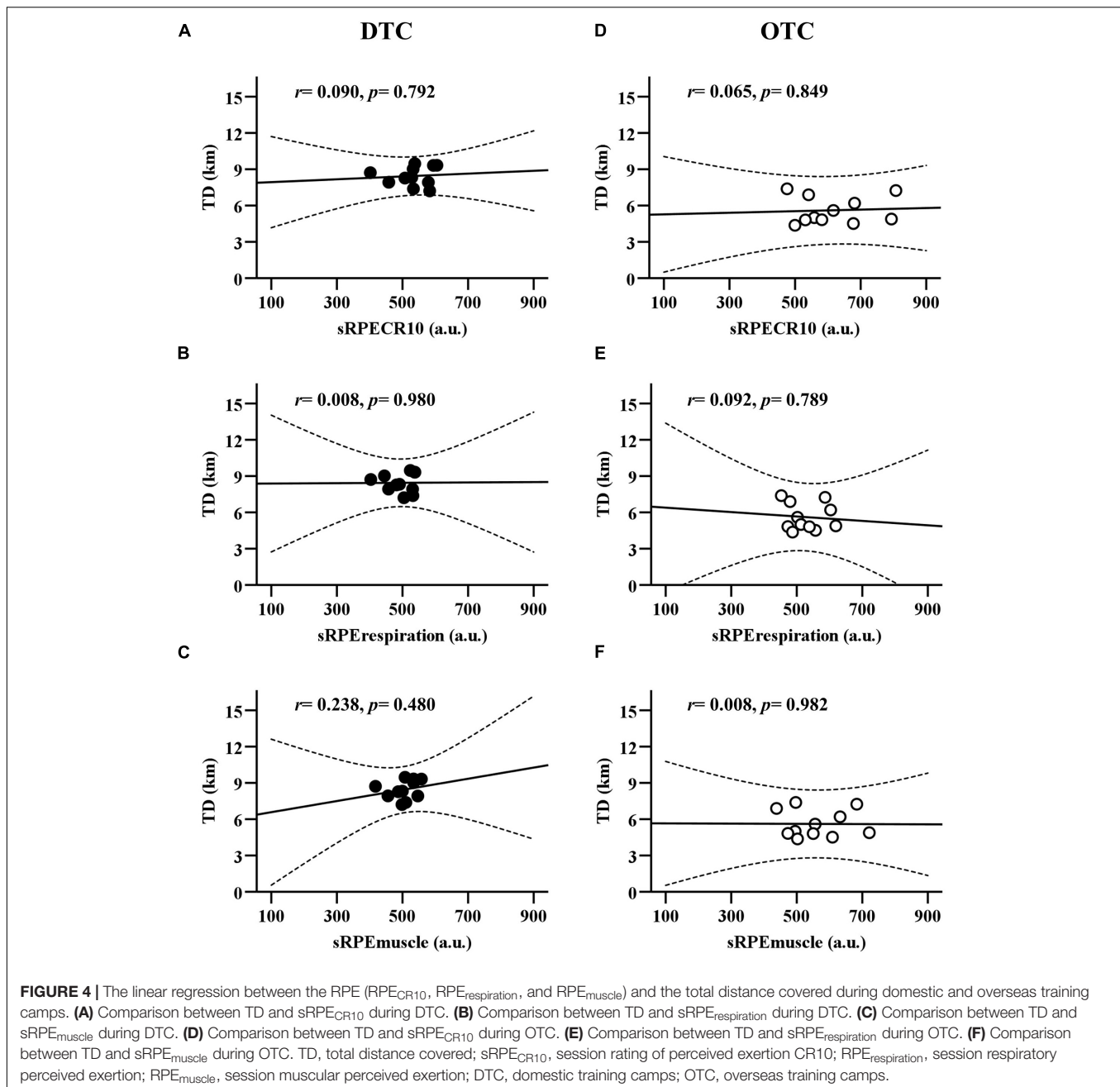
We observed a positive association between RPE_{respiration} and RPE_{muscle} scales during both DTC and OTC. These



findings are supported with previous studies that observed longitudinal changes in $RPE_{respiration}$ and RPE_{muscle} scales in young professional adult soccer players during weekly training sessions and in-season matches (Los Arcos et al., 2014, 2016, 2017). The RPE_{muscle} and $RPE_{respiration}$ scales showed similar features when quantifying the training load during weekly training sessions of a competitive period in professional soccer players (Los Arcos et al., 2017). Furthermore, different RPE scales permit researchers to obtain similar patterns of internal load during short-term specific training sessions. McLaren et al. (2020) recently demonstrated the usefulness of $RPE_{respiration}$ and RPE_{muscle} scales in detecting improvements in high-intensity running profiles during a 2-week repeated sprint training

intervention in semiprofessional soccer players. In this study, the positive association identified in all RPE scales indicates the potential usefulness of pictorial RPE measures in quantifying internal load in futsal training.

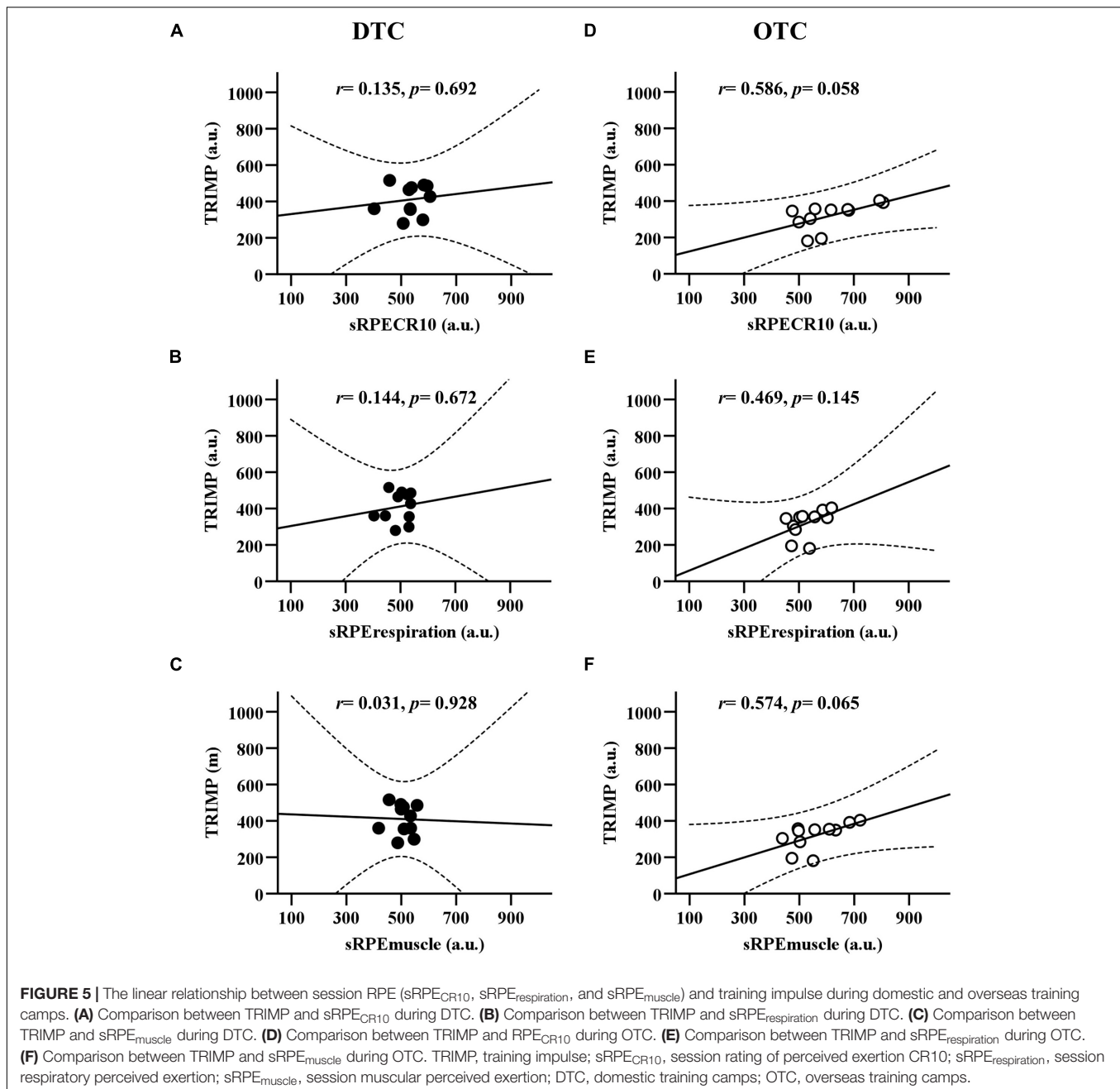
The results of linear regressions show no relationships between RPE scales and TD/TRIMP. This finding indicated independent markers of training load monitoring between the subjective and objective tools. Subjective assessment of training load can be used to understand the variation in an individual's perception of daily changes in psychological and physiological status during sports training. Conversely, objective assessment of training load provides a quantitative measure of physiological responses and exercise performance



to understand the accumulation of training and match loads. Collectively, our findings suggested no relationship between RPE scales and TRIMP/TD variables during futsal DTC and OTC. A combination of subjective and objective assessments to evaluate training loads in futsal training is recommended.

It should be noted that a within-subject approach was used during this study period (Costa et al., 2019, 2021; Figueiredo et al., 2021). Compared to TD and TRIMP, our results demonstrated that three different RPE scales showed similar dispersion and tendencies between individual and group values across the DTC. However, such observations may not exist during the OTC (see Figure 2). It is possibly related to the difference in training tasks

among the OTC. In our study samples, the OTC consisted of several friendly matches to test the team's competitive level. Costa et al. (2021) found that a training camp consisting of training sessions and friendly matches demonstrated a large variability of $sRPE_{CR10}$ in female football players. Interestingly, there was a long interval between DTC 5 and DTC 6 (83 days) in our study. Despite the similar training contents with DTC 2, 3, and 4, a large dispersion of individual training load was observed in DTC 6. This finding was related to the initial fitness level before the training camp and competition status in the participants' home teams (2-week break during the Chinese New Year, and no competition schedule). During the periodic training camps,



coaches and strength and conditioning practitioners should consider the large individual difference in fitness level when the players return for training camps.

The first limitation of this study is that respiratory and muscular RPE used pictorial rating to quantify the perception of sensory feedback, compared to arbitrary units used in RPE_{CR10} . This study players had extensive experience using the pictorial $RPE_{respiration}$, RPE_{muscle} , and $sRPE_{CR10}$ measurements. Despite similar reports among different RPE scales found in our study, there still exists the potential that other populations, such as players with less training experience or those who are not familiar with this method, may show differing results. Second, the

different perceived efforts might be related to the players' initial fitness capacity. This study did not report the association between fitness capacity and individual perception of training stresses (Azcarate et al., 2020). A potential bias of the individual peak HR that changed across the timeline of training camps could be the third limitation of this study. The peak HR determined during the Yo-Yo intermittent recovery level 1 test in the first OTC may not be equivalent to actual HR_{max} in each training camp engagement. Finally, the task difference during DTC and OTC may result in large intraindividual variability in this study. The main focus of friendly matches during OTC could lead to a fluctuation of daily training loads and recovery status to more/less playing time

per individual. Future studies need to measure these individual changes during the training camps.

The present findings revealed significant positive correlations among RPE_{CR10} and pictorial RPE_{respiration} and RPE_{muscle} during the futsal DTC and OTC. Our study reported that pictorial RPE measures and RPE_{CR10} have similar outcomes as monitoring tools during futsal training. Coaches and sports practitioners are encouraged to use one of the RPE measures concurrently with time spent in HR zones and TD measures during futsal training camps.

CONCLUSION

In conclusion, TD and TRIMP of short-term DTC were larger than that of short-term OTC. However, the RPE_{CR10} is higher during OTC than that of DTC. No differences in perceived measures of muscular and respiratory RPE were identified. Additionally, three different RPE measures showed similar individual dispersion and group tendency across the DTC. The interpretation of perceived efforts *via* respiratory, muscular, and Borg CR10 quantifications provides a valuable resource in monitoring internal load in futsal DTC and OTC. No relationships among the perceived measures, TRIMP, and TD were observed in this study highlighting that it is essential to implement multiple tools when recording training loads in futsal players. Using a combination of subjective and objective measures to monitor training loads during short-term futsal training camps is warranted.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

REFERENCES

- Álvarez, J. C. B., D'ottavio, S., Vera, J. G., and Castagna, C. (2009). Aerobic fitness in futsal players of different competitive level. *J. Strength Cond. Res.* 23, 2163–2166. doi: 10.1519/JSC.0b013e3181b7f8ad
- Azcárate, U., Los Arcos, A., Jiménez-Reyes, P., and Yanci, J. (2020). Are acceleration and cardiovascular capacities related to perceived load in professional soccer players? *Res. Sports Med.* 28, 27–41. doi: 10.1080/15438627.2019.1644642
- Barbero-Alvarez, J. C., Soto, V. M., Barbero-Alvarez, V., and Granda-Vera, J. (2008). Match analysis and heart rate of futsal players during competition. *J. Sports Sci.* 26, 63–73. doi: 10.1080/02640410701287289
- Borg, G. (1998). *Perceived Exertion and Pain Scales*. Champaign, IL: Human Kinetics.
- Bourdon, P. C., Cardinale, M., Murray, A., Gastin, P., Kellmann, M., Varley, M. C., et al. (2017). Monitoring athlete training loads: consensus statement. *Int. J. Sports Physiol. Perform.* 12, 161–170. doi: 10.1123/IJSP.2017-0208
- Chen, Y.-S., Clemente, F. M., Bezerra, P., and Lu, Y.-X. (2020). Ultra-short-term and short-term heart rate variability recording during training camps and an international tournament in U-20 national futsal players. *Int. J. Environ. Res. Public Health* 17:775. doi: 10.3390/ijerph17030775
- Clemente, F. M., Rabbani, A., and Araújo, J. P. (2019). Ratings of perceived recovery and exertion in elite youth soccer players: interchangeability of 10-point and 100-point scales. *Physiol. Behav.* 210:112641. doi: 10.1016/j.physbeh.2019.112641
- Clemente, F. M., Silva, A. F., Sarmiento, H., Ramirez-Campillo, R., Chiu, Y.-W., Lu, Y.-X., et al. (2020). Psychobiological changes during national futsal team training camps and their relationship with training load. *Int. J. Environ. Res. Public Health* 17:1843. doi: 10.3390/ijerph17061843
- Corrêa, U. C., de Pinho, S. T., da Silva, S. L., Clavijo, F. A., Souza, T. O., and Tani, G. (2016). Revealing the decision-making of dribbling in the sport of futsal. *J. Sports Sci.* 34, 2321–2328. doi: 10.1080/02640414.2016.1232488
- Costa, J., Figueiredo, P., Nakamura, F., Rago, V., Rebelo, A., and Brito, J. (2019). Intra-individual variability of sleep and nocturnal cardiac autonomic activity in elite female soccer players during an international tournament. *PLoS One* 14:e0218635. doi: 10.1371/journal.pone.0218635
- Costa, J. A., Figueiredo, P., Nakamura, F. Y., Rebelo, A., and Brito, J. (2021). Monitoring individual sleep and nocturnal heart rate variability indices: the impact of training and match schedule and load in high-level female soccer players. *Front. Physiol.* 12:678462. doi: 10.3389/fphys.2021.678462
- Edwards, S. (1993). "High performance training and racing," in *The Heart Rate Monitor Book*, ed. S. Edwards (Sacramento, CA: Feet Fleet Press), 113–123.
- Figueiredo, P., Costa, J., Lastella, M., Morais, J., and Brito, J. (2021). Sleep indices and cardiac autonomic activity responses during an international tournament in a youth national soccer team. *Int. J. Environ. Res. Public Health* 18:2076. doi: 10.3390/ijerph18042076
- Foster, C., Florhaug, J. A., Franklin, J., Gottschall, L., Hrovatin, L. A., Parker, S., et al. (2001). A new approach to monitoring exercise training. *J. Strength Cond. Res.* 15, 109–115.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Human Ethics Committee of the University of Taipei. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

Y-XL contributed to the study conceptualization, project administration, investigation, methodology, and writing (including reviewing and editing) of the manuscript. FMC and PB contributed to the study conceptualization and writing (including reviewing and editing) of the manuscript. ZC-M and C-HC contributed to the study data analysis and writing (including reviewing and editing) of the manuscript. S-CC contributed to the statistical analysis and writing (including reviewing and editing) of the manuscript. C-DK and Y-SC contributed to the study conceptualization, methodology, supervision, and writing (including reviewing and editing) of the manuscript. All authors contributed to the article and approved the submitted version.

FUNDING

This study was supported by the grant V96C1-153 of Taipei Veterans General Hospital, Taiwan.

ACKNOWLEDGMENTS

The authors would like to thank the head coach Adil Amarante, team staff, and players who volunteered for this study.

- Haddad, M., Stylianides, G., Djaoui, L., Dellal, A., and Chamari, K. (2017). Session-RPE method for training load monitoring: validity, ecological usefulness, and influencing factors. [mini review]. *Front. Neurosci.* 11:612. doi: 10.3389/fnins.2017.00612
- Halson, S. L. (2014). Monitoring training load to understand fatigue in athletes. *Sports Med.* 44, 139–147. doi: 10.1007/s40279-014-0253-z
- Hopkins, W. G., Marshall, S. W., Batterham, A. M., and Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Med. Sci. Sports Exerc.* 41, 3–12. doi: 10.1249/MSS.0b013e31818cb278
- Impellizzeri, F., Rampinini, E., Coutts, A., Sassi, A., and Marcora, S. (2004). Use of RPE-based training load in soccer. *Med. Sci. Sports Exerc.* 36, 1042–1047. doi: 10.1249/01.mss.0000128199.23901.2f
- Impellizzeri, F. M., Marcora, S. M., and Coutts, A. J. (2019). Internal and external training load: 15 years on. *Int. J. Sports Physiol. Perform.* 14, 270–273. doi: 10.1123/ijsp.2018-0935
- Los Arcos, A., Javier, Y., Mendiguchia, J., and Gorostiaga, E. (2014). Rating of muscular and respiratory perceived exertion in professional soccer players. *J. Strength Cond. Res.* 28, 3280–3288. doi: 10.1519/JSC.0000000000000540
- Los Arcos, A., Mendez-Villanueva, A., and Martínez-Santos, R. (2017). In-season training periodization of professional soccer players. *Biol. Sport* 34, 149–155. doi: 10.5114/biolport.2017.64588
- Los Arcos, A., Méndez-Villanueva, A., Yanci, J., and Martínez-Santos, R. (2016). Respiratory and muscular perceived exertion during official games in professional soccer players. *Int. J. Sports Physiol. Perform.* 11, 301–304. doi: 10.1123/ijsp.2015-0270
- Lu, Y.-X., Clemente, F. M., Bezerra, J. P., and Chen, Y.-S. (2019). Training load and recovery status during a short-term overseas training camp in Taiwan futsal players. *Hum. Mov.* 18, 98–105. doi: 10.5114/hm.2018.83218
- McLaren, S. J., Graham, M., Spears, I. R., and Weston, M. (2016). The sensitivity of differential ratings of perceived exertion as measures of internal load. *Int. J. Sports Physiol. Perform.* 11, 404–406. doi: 10.1123/ijsp.2015-0223
- McLaren, S. J., Taylor, J. M., Macpherson, T. W., Spears, I. R., and Weston, M. (2020). Systematic reductions in differential ratings of perceived exertion across a 2-week repeated-sprint-training intervention that improved soccer players' high-speed-running abilities. *Int. J. Sports Physiol. Perform.* 15, 1414–1421. doi: 10.1123/ijsp.2019-0568
- Naser, N., Ali, A., and Macadam, P. (2017). Physical and physiological demands of futsal. *J. Exerc. Sci. Fitness* 15, 76–80. doi: 10.1016/j.jesf.2017.09.001
- Pianosi, P. T., Huebner, M., Zhang, Z., and McGrath, P. J. (2014). Dalhousie dyspnea and perceived exertion scales: psychophysical properties in children and adolescents. *Respir. Physiol. Neurobiol.* 199, 34–40. doi: 10.1016/j.resp.2014.04.003
- Pianosi, P. T., Huebner, M., Zhang, Z., Turchetta, A., and McGrath, P. J. (2015). Dalhousie pictorial scales measuring dyspnea and perceived exertion during exercise for children and adolescents. *Ann. Am. Thorac. Soc.* 12, 718–726. doi: 10.1513/AnnalsATS.201410-477OC
- Pianosi, P. T., Zhang, Z., Hernandez, P., and Huebner, M. (2016). Measuring dyspnea and perceived exertion in healthy adults and with respiratory disease: new pictorial scales. *Sports Med. Open* 2:17. doi: 10.1186/s40798-015-0038-4
- Spyrou, K., Freitas, T. T., Marin-Cascales, E., and Alcaraz, P. E. (2020). Physical and physiological match-play demands and player characteristics in futsal: a systematic review. *Front. Psychol.* 11:569897. doi: 10.3389/fpsyg.2020.569897
- Stochi de Oliveira, R., and Borin, J. P. (2021). Monitoring and behavior of biomotor skills in futsal athletes during a season. *Front. Psychol.* 12:661262. doi: 10.3389/fpsyg.2021.661262
- Wright, M. D., Songane, F., Emmonds, S., Chesterton, P., Weston, M., and McLaren, S. J. (2020). Differential ratings of perceived match and training exertion in girls' soccer. *Int. J. Sports Physiol. Perform.* 15, 1315–1323. doi: 10.1123/ijsp.2019-0595

Conflict of Interest: C-DK is a consultant for Leadtek Research Inc.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Copyright © 2022 Lu, Clemente, Bezerra, Crowley-McHattan, Cheng, Chien, Kuo and Chen. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.