



Assessing the Effects of Transition Small-Sided Game Format and Work-to-Rest Ratio on Training Load in Soccer Players

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Accepted for Publication: August 30, 2026

Published: September 28, 2026

DOI: 10.17309/tmfv.2026.5.13

Abstract

Background. Small-sided games (SSGs) are widely used in soccer training to simultaneously develop physical and physiological performance. However, transition-specific SSG formats combined with work-to-rest ratio manipulation may further influence training load, although their interactive effects remain unclear.

Objectives. This study aimed to examine the effects of transition small-sided game format and work-to-rest ratio on internal and external training load in university soccer players.

Materials and Methods. Eighteen male university soccer players participated in this study. Two transition game formats (3v3v3+2 and 3v3v3+2 Change) and four work-to-rest ratios (4:4, 4:2, 2:2, and 2:1) were applied. Internal load was assessed using heart rate responses, and external load was measured using Global Navigation Satellite System (GNSS) devices. A two-way repeated-measures ANOVA was used to analyze the data.

Results. Both the work-to-rest ratio and the playing format significantly affected internal load, with higher mean heart rate and greater time spent above 80% of HR under shorter recovery (4:2), as well as higher mean heart rate under the No-Change format overall. External load variables showed significant main and interaction effects, with the 2:2 ratio producing the highest total distance, acceleration, and deceleration, while and the 3v3v3+2 Change format combined with the 2:2 ratio eliciting the greatest high-intensity running and peak speed. Maximum heart rate indicated a significant Format × Work-to-Rest interaction, although no individual condition-pair comparison remained significant after Bonferroni correction.

Conclusions. The findings suggest that combining transition game format with an appropriate work-to-rest ratio can be used as an effective strategy for manipulating training loads in soccer players.

Keywords: external load, internal load, small-sided games, soccer, training load.

Introduction

Small-sided games (SSGs) are a fundamental component of contemporary soccer training because of their capacity to simultaneously develop physical, technical, and tactical attributes within sport-specific contexts (Nagy et al., 2020; Farhani et al., 2022). Unlike isolated conditioning drills, SSGs replicate the intermittent, unpredictable nature of competitive match play, making them an ecologically valid and time-efficient training tool (Chen et al., 2023; de Dios-Álvarez et al., 2024). As a result, SSGs are widely adopted

across elite and sub-elite levels to improve soccer-specific fitness while maintaining tactical relevance.

Training load during SSGs is highly sensitive to structural manipulations, including player number, pitch dimensions, bout duration, and work-to-rest ratio (Alcántara et al., 2021; Farhani et al., 2025), enabling coaches to selectively target physiological adaptations from aerobic capacity to high-intensity repeated-effort performance (Nagy et al., 2020; Farhani et al., 2022). Among these variables, work-to-rest ratio is particularly critical, as it governs recovery between bouts and determines the cumulative and peak demands placed on players. Beyond conventional SSG configurations, transitional moments the rapid shift between attacking and defending phases following a change in possession are among the most physically and tactically demanding phases of match play,

characterized by elevated high-speed running, accelerations, and cognitive load, often surpassing the demands recorded during sustained possession sequences (Bortnik et al., 2022, 2024). Physical demands during transitional play also differ across playing positions, highlighting the positional specificity required in training design (Bortnik et al., 2024).

In response, transition-specific SSG formats transition games have emerged as a targeted training modality. Asian-Clemente et al. (2022) demonstrated that transition games can elicit high-speed running volumes comparable to competition, suggesting their potential to replicate worst-case match demands, and varying player number within transition games substantially modulates physical loading (Asian-Clemente et al., 2024a), while conventional SSGs may not consistently replicate the most extreme physical scenarios experienced in match play (de Dios-Álvarez et al., 2024).

Despite growing interest in transition game formats and the well-established influence of work-to-rest manipulation on training load in conventional SSGs, the interaction between these two variables remains insufficiently examined, and no study has systematically investigated how different transition game formats combined with varying work-to-rest ratios affect overall training load in soccer players. This gap limits practitioners' ability to make evidence-based decisions when designing sessions intended to replicate the physiological demands of competitive transitions. Therefore, the purpose of this study was to examine the effects of transition game format and work-to-rest ratio on training load in small-sided soccer games, to provide practical recommendations for optimizing the specificity and effectiveness of soccer conditioning programs.

Materials and Methods

Participants

Eighteen male university soccer players participated in this study (age: 19.6 ± 0.69 years; body mass: 65.07 ± 8.51 kg; height: 173.61 ± 7.36 cm; body mass index: 21.3 ± 2.03 kg·m⁻²; body fat: $13.23 \pm 3.94\%$; VO₂max: 50.94 ± 2.58 mL·kg⁻¹·min⁻¹). All participants were healthy, had at least 5 years of competitive soccer experience at the high school or university level, and trained at least 5 days per week; goalkeepers, injured players, and those unable to complete the protocol were excluded. Participants were recruited using purposive sampling. All players completed the Yo-Yo Intermittent Recovery Test Level 1 (YYIR1) to estimate VO₂max, calculated using the equation of Karakoç et al. (2012): $VO_{2max} \text{ (mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}) = \text{distance (m)} \times 0.0084 + 36.4$. Based on performance ranking, the top 22 players were selected; 18 were randomly assigned into six groups of three, while the remaining four (ranked 19–22) acted as neutral players during the games but were not included in the analysis. Group allocation ensured no significant baseline differences between groups. All participants provided written informed consent, and the study was approved by the Ethics Committee of Kasem Bundit University, Thailand (KBU-HREC 009/69), in accordance with the Declaration of Helsinki.

Procedure

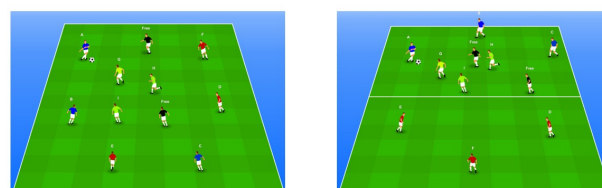
On each experimental day, participants drew lots to determine the SSG format and work-to-rest ratio to be

completed; the order of all eight experimental conditions (two SSG formats $\times$ four work-to-rest ratios) was fully randomized for each participant to control for potential order effects. All sessions began with a standardized 15-minute warm-up (5 min light jogging, 8 min dynamic stretching, and 2 min neuromuscular activation comprising three 10-m maximal sprints; Eniseler et al., 2017). Both formats were played as 3v3v3+2 on a 55 $\times$ 20-m pitch (~ 100 m² per player), following prior recommendations (Dimitriadis et al., 2022).

In the transition SSG without spatial change (3v3v3+2), players were divided into three colour-coded teams of three; two teams collaborated to maintain possession while the third defended and attempted to regain the ball, transferring it to the non-possessioning team before transitioning to attack, while the team losing the ball immediately assumed the defensive role. In the transition SSG with spatial change (3v3v3+2 Change), the possessioning team was required to complete seven consecutive passes before transferring the ball to the opposite zone; if the defending team intercepted or dispossessed the attackers, they transferred the ball to the far zone, and the team losing possession transitioned to defense (Figure 1).

In both formats, two neutral players (floaters) supported the attacking team (Clemente, 2022). Unlimited ball touches were permitted, and a replacement ball was reintroduced immediately whenever the ball left play, with consistent verbal encouragement from coaches throughout.

The work-to-rest ratios applied were 1:1 and 1:0.5. Under 1:1, participants completed either four 4-minute sets with 4-minute recovery, or eight 2-minute sets with 2-minute recovery; under 1:0.5, participants completed either four 4-minute sets with 2-minute recovery, or eight 2-minute sets with 1-minute recovery (Clemente, 2022). Immediately following each session, heart rate (HR) responses and locomotor data were recorded. HR variables included peak HR, mean HR, and time spent in the 70–79%, 80–89%, and 90–100% HRmax zones (Nagy et al., 2020). Locomotor variables comprised total distance, high-speed running (>19.8 km·h⁻¹), sprint distance (>25.2 km·h⁻¹), peak speed, and the number of accelerations and decelerations (>2.5 m·s⁻²) (Beato et al., 2023). Sessions were conducted between 16:00–18:00 h at 30–33°C ambient temperature, with a minimum 48-hour washout period between sessions (Papanikolaou et al., 2021).



1.) SSG Format 3v3v3+2

2.) SSG Format 3v3v3+2 Change

Fig. 1. SSG Transition Format Training (3v3v3+2).

Instrument

Internal training load was assessed via HR responses using a Polar H10 chest strap (Polar Electro Oy, Kempele, Finland), a device with demonstrated validity and reliability at rest and during incremental exercise (Schaffarczyk et al.,

2022). HRmax, HRmean, and the percentage of time spent in the 70–79% (moderate), 80–89% (high), and 90–100% (very high) HRmax zones were extracted, consistent with classification frameworks applied in SSG research (Nagy et al., 2020a). Individual HRmax was estimated using the age-predicted formula ($220 - \text{age in years}$), given the impracticality of maximal exercise testing within this field-based training protocol.

External load was quantified using 10 Hz global navigation satellite system (GNSS) units (PlayerData Edge, Scotland; Wilmot et al., 2025); each participant was assigned the same device throughout the study, in line with recommended GNSS measurement practice for team sports (Bataller-Cervero et al., 2019; Beato et al., 2018). Devices were activated at least 15 minutes before each session, and data collection began only when a minimum of eight satellites and a horizontal dilution of precision (HDOP) value below 1.0 were confirmed, in line with recommended GNSS data-quality procedures (Malone et al., 2017). Units were secured in a custom-fitted vest between the scapulae, and raw data were downloaded and processed immediately after each session by a qualified sports scientist. The external load variables analyzed were total distance, high-intensity running distance (HIR; $>19.8 \text{ km}\cdot\text{h}^{-1}$), sprint distance (SPR; $>25.2 \text{ km}\cdot\text{h}^{-1}$), peak speed, accelerations (ACC; $>2.5 \text{ m}\cdot\text{s}^{-2}$), and decelerations (DEC; $>2.5 \text{ m}\cdot\text{s}^{-2}$), among the most commonly reported indicators of physical demand in SSG and match-play contexts (Beato et al., 2023).

Data Analysis

All data are presented as mean $\pm$ standard deviation (SD). A two-way repeated-measures ANOVA examined the main effects of playing format (3v3v3+2 vs. 3v3v3+2 Change) and work-to-rest condition (4:4, 4:2, 2:2, and 2:1) as within-subject factors, and their interaction, on all internal and external load variables. Normality was verified using the Shapiro–Wilk test, and sphericity was assessed using Mauchly’s test, with the Greenhouse–Geisser correction applied where violated. Significant effects were followed by Bonferroni-adjusted post hoc comparisons. Effect sizes were reported as partial eta squared (η^2p) and interpreted as small (≥ 0.01), moderate (≥ 0.06), and large (≥ 0.14). Statistical significance was set at $p < 0.05$. All analyses were performed

using Jamovi (version 2.6.17; The Jamovi Project, Sydney, Australia). A priori sample size estimation was performed using G*Power (version 3.1; Faul et al., 2007), specifying an effect size of 1.1, $\alpha = 0.05$, and power ($1 - \beta$) = 0.95, which indicated a minimum required sample of 16 participants; allowing for an anticipated attrition rate of 10%, 22 players were recruited, of whom 18 were retained for the final analysis after ranking on YYIR1-derived VO2max.

Results

Internal and external load values following the SSG sessions are presented in Table 1 and Table 2. The two-way repeated-measures ANOVA results, separated into the main effect of format, the main effect of work-to-rest ratio, and their interaction, are reported for each variable in Table 3 (internal load) and Table 4 (external load).

indicating similar peak cardiovascular responses. HRmean differed significantly ($150.67\text{--}165.44 \text{ bpm}$; $p = .027$; $\eta^2p = 0.168$), with higher values under shorter recovery (4:2 and 2:1), particularly in the 3v3v3+2 format ($165.44 \pm 11.73 \text{ bpm}$ at 2:1). %HRmean showed a similar trend but did not reach significance ($75.67\text{--}83.00\%$; $p = .063$; $\eta^2p = 0.164$). Time at 80%HR differed significantly ($31.67\text{--}49.67 \text{ min}$; $p = .016$; $\eta^2p = 0.162$), with greater exposure under reduced recovery, while 70%HR ($p = .224$) and 90%HR ($p = .164$) did not differ significantly. Overall, reducing recovery duration increased mean physiological load and time at high intensity, with large effect sizes ($\eta^2p \geq 0.14$).

In the Change condition ($6.42 \pm 0.54 \text{ m}\cdot\text{s}^{-1}$). Acceleration ($17.00\text{--}26.44$; $p = .004$; $\eta^2p = 0.232$) and deceleration ($20.44\text{--}30.89$; $p = .001$; $\eta^2p = 0.233$) were also highest at 2:2. Sprint distance differed significantly overall ($0.00\text{--}2.44 \text{ m}$; $p = .025$; $\eta^2p = 0.123$), though no pairwise comparisons survived Bonferroni correction. Overall, the 2:2 work-to-rest ratio elicited the greatest total distance regardless of format, whereas the 3v3v3+2 Change format combined with 2:2 produced the greatest high-intensity running, peak speed, and deceleration count; effect sizes were moderate for sprint distance ($\eta^2p = 0.123$) and large for all other variables ($\eta^2p = 0.232\text{--}0.818$).

Post hoc comparisons (Bonferroni-adjusted) further clarify these separated effects. For HRmean, values were higher under 4:2 than 4:4 (mean difference [MD] = -12.67 bpm ; $p < .001$), and higher under the No-Change format than

Table 1. Internal loads during different SSG formats

Variable	Small-Sided Game Formats (n=18)				Small-Sided Game Formats (n=18)				F ¹	p ¹	η ² p ¹
	3v3v3+2				3v3v3+2 Change						
	4:4	4:2	2:2	2:1	4:4	4:2	2:2	2:1			
HRmax (bpm)	182.11±7.46	183.78±6.19	185.67±5.45	184.00±6.58	185.67±10.40	180.44±9.69	177.56±8.77	182.89±9.66	1.95	0.119	0.103
%HRmax	91.22±3.84	92.22±3.02	93.11±2.81	92.22±3.25	93.11±5.21	90.33±4.90	89.00±4.42	91.67±4.45	2.13	0.092	0.111
HRmean (bpm)	151.67±9.36	164.33±8.80*	155.56±13.01	165.44±11.73*	150.67±13.66	159.22±12.20	151.33±9.09	151.00±11.73	3.44	0.027	0.168
%HRmean	75.78±4.62	82.33±4.34*	78.00±6.53	83.00±5.94*	75.67±6.81	79.78±6.30	76.00±4.55	82.56±5.94	3.35	0.063	0.164
70%HR (%)	27.00±10.14	21.78±8.36	28.89±7.83	22.44±16.96	25.33±7.31	25.11±13.49	31.44±9.69	26.33±12.28	1.49	0.224	0.081
80%HR (%)	36.00±11.19	49.67±16.34*	36.33±13.00	47.11±17.70*	31.67±14.71	43.11±19.22	35.22±11.85	48.44±24.50*	3.28	0.016	0.162
90%HR (%)	6.44±12.88	17.67±22.92	11.78±16.43	21.78±25.35	10.56±18.46	13.89±25.97	4.78±13.55	11.22±10.25	1.69	0.164	0.091

* Significant difference compared with 3v3v3+2 (4:4) ($p < 0.05$).

Table 2. External loads during different SSG formats

Variable	Small-Sided Game Formats (n=18)				Small-Sided Game Formats (n=18)				F ¹	p ¹	η ² p ¹
	3v3v3+2				3v3v3+2 Change						
	4:4	4:2	2:2	2:1	4:4	4:2	2:2	2:1			
Total Distance (m)	2197±261	2003±207*	2382±233 #	2214±270	2134±304	1892±121*	2132±270 #	1838±254*	76.6	<.001	0.818
High Intensity (m)	18.89±16.49	5.56±14.77*	18.89±16.83	18.78±15.73	47.56±67.17*	13.56±27.65	104.67±88.75*	11.56±11.47	10.2	<.001	0.375
Sprint (m)	0	0.56±1.62	0	1.33±3.88	0.67±1.94	0	2.44±4.73	0	2.39	0.025	0.123
Max Speed (m/s)	5.99±0.41	5.48±0.69*	5.99±0.41	5.99±0.76	6.06±0.65	5.51±0.45*	6.42±0.54 #	5.52±0.49*	6.25	<.001	0.269
ACC (n)	25.33±6.54	21.22±6.19	25.44±4.95	21.78±8.92	20.56±7.67	18.89±4.79*	26.44±3.63	17.00±5.09*	5.13	0.004	0.232
DEC (n)	24.89±7.78	20.44±10.01	27.11±7.98	22.78±10.80	23.78±7.73	24.67±6.04	30.89±8.05 #	20.44±6.55	5.16	0.001	0.233

* Significant difference compared with 3v3v3+2 (4:4) (p < 0.05). # Significant difference compared with 3v3v3+2 (4:2) (p < 0.05).

Table 3. Two-way repeated-measures ANOVA results for internal load variables (main effects and interaction).

Variable	Format (3v3v3+2 vs. Change)			Work-to-Rest Ratio			Format × Work-to-Rest		
	F	p	η^2p	F	p	η^2p	F	p	η^2p
HRmax (bpm)	1.846	0.192	0.098	0.666	0.577	0.038	3.252	0.029	0.161
%HRmax	1.882	0.188	0.100	0.678	0.569	0.038	3.668	0.018	0.177
HRmean (bpm)	5.61	0.030	0.248	3.81	0.015	0.183	1.85	0.150	0.098
%HRmean	0.041	0.843	0.002	7.217	<.001	0.298	1.16	0.334	0.064
70%HR (%)	0.705	0.413	0.040	2.508	0.069	0.129	0.654	0.584	0.037
80%HR (%)	1.101	0.309	0.061	7.349	<.001	0.302	0.373	0.773	0.021
90%HR (%)	1.77	0.201	0.094	2.08	0.114	0.109	1.2	0.319	0.066

df = 1, 17 for the main effect of Format; df = 3, 51 for the main effect of Work-to-Rest ratio and for the Format × Work-to-Rest interaction. F and p values are as computed in the two-way repeated-measures ANOVA (Type III sums of squares); η^2p (partial eta squared) was derived from F and the corresponding degrees of freedom. Bonferroni-adjusted post hoc comparisons for each significant effect are described in the Results text.

Table 4. Two-way repeated-measures ANOVA results for external load variables (main effects and interaction).

Variable	Format (3v3v3+2 vs. Change)			Work-to-Rest Ratio			Format × Work-to-Rest		
	F	p	η^2p	F	p	η^2p	F	p	η^2p
Total Distance (m)	213	<.001	0.926	65.4	<.001	0.794	37.6	<.001	0.689
High Intensity (m)	14.99	0.001	0.469	9.97	<.001	0.370	8.64	<.001	0.337
Sprint (m)	0.525	0.479	0.030	1.091	0.361	0.060	4.721	0.013	0.217
Max Speed (m/s)	0.028	0.868	0.002	8.293	<.001	0.328	5.682	0.002	0.251
ACC (n)	8.73	0.009	0.339	8.16	<.001	0.324	1.54	0.215	0.083
DEC (n)	1.06	0.318	0.059	13.59	<.001	0.444	1.85	0.150	0.098

df = 1, 17 for the main effect of Format; df = 3, 51 for the main effect of Work-to-Rest ratio and for the Format × Work-to-Rest interaction, except the Sprint distance × interaction term, for which Mauchly's test indicated a sphericity violation and the reported p value reflects the Greenhouse–Geisser correction (F and η^2p are unaffected by this correction). Bonferroni-adjusted post hoc comparisons for each significant effect are described in the Results text.

the Change format overall (MD = 6.19 bpm; p = .030). For %HRmean, 4:2 exceeded 4:4 (MD = -6.56%; p < .001). For time at 80%HR, 4:2 exceeded both 4:4 (MD = -12.56%; p = .002) and 2:2 (MD = 10.61%; p = .034). For HRmax and %HRmax, although the Format × Work-to-Rest interaction reached significance (Table 3), no individual pairwise comparison survived Bonferroni correction (all p ≥ .109), indicating a diffuse rather than localized interaction pattern.

Post hoc comparisons (Bonferroni-adjusted) show that total distance was higher under the No-Change format than the Change format overall (MD = 200 m; p < .001), and the Format × Work-to-Rest interaction was driven primarily by the 2:2 conditions in both formats, which exceeded most other combinations (all p ≤ .018). High-intensity running distance was higher under the Change format overall (MD = -28.8 m; p = .001), and the interaction was

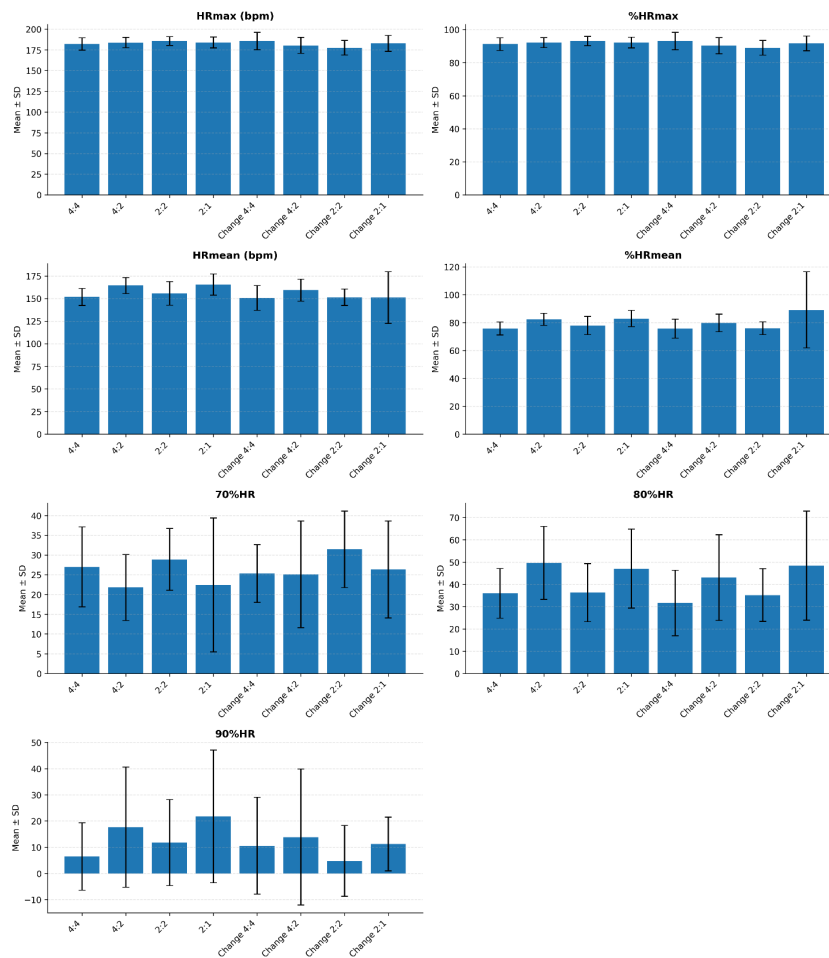


Fig. 2. Internal load responses across SSG formats.

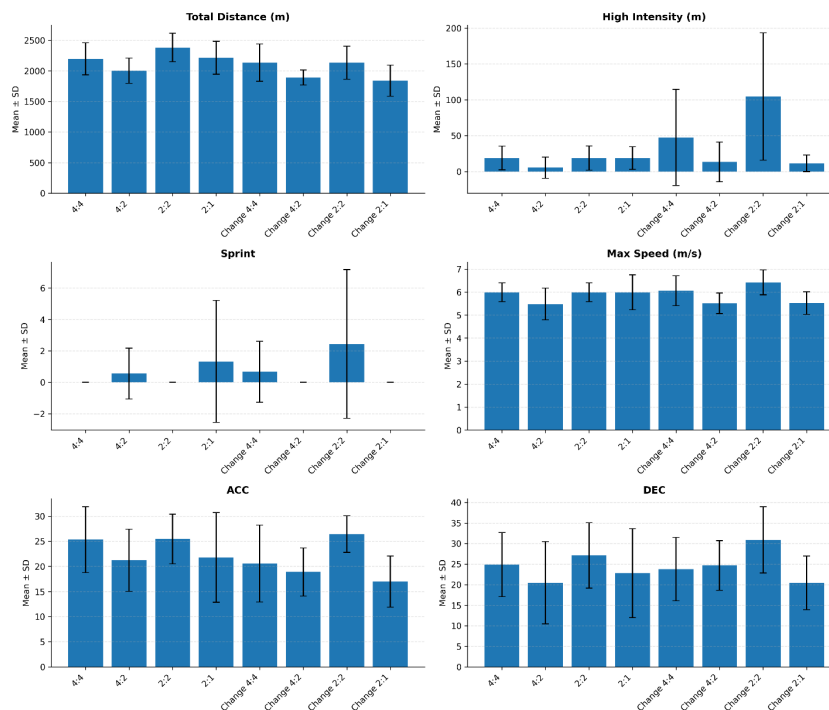


Fig. 3. External load responses across SSG formats.

driven by the Change-format 2:2 condition, which exceeded every other combination (all $p \leq .045$). Maximum speed showed a comparable pattern, with the Change-format 2:2 condition exceeding the other Change-format conditions (all $p \leq .047$). Regarding sprint distance, cross-checking the Format $\times$ Work-to-Rest interaction term against the authors' original Jamovi statistical output identified a discrepancy: the summary report had listed $p = .115$ for this term, but the native output shows $F = 4.721$, $p = .013$ (Greenhouse-Geisser-corrected for a sphericity violation), which is significant. Table 4 and this response have been corrected accordingly. As with HRmax and %HRmax above, no individual pairwise comparison for this interaction survived Bonferroni correction (all $p = 1.000$), so the significant interaction should be interpreted as a diffuse pattern across conditions rather than attributable to any single condition pair.

Figure 2 illustrates the internal load responses across SSG formats and work-to-rest conditions. HRmax and %HRmax remain relatively stable across all conditions, supporting the absence of significant differences, whereas HRmean (≈ 150 – 165 bpm) and %HRmean (≈ 75 – 83%) increase under shorter recovery (4:2 and 2:1), reflecting greater accumulated physiological stress; time spent at 80%HR shows a similar increase under reduced recovery, consistent with the moderate effect sizes observed statistically.

Figure 3 shows that total distance peaks in the 2:2 condition (≈ 2382 m), while high-intensity running is markedly higher in the transition format with spatial change (≈ 104.67 m); max speed is also greatest in this condition (≈ 6.42 m·s⁻¹). Acceleration (≈ 26.44) and deceleration (≈ 30.89) are consistently elevated at 2:2, indicating greater movement demands, while sprint distance remains low (0– 2.44 m) and variable across conditions. Overall, the graphical trends support the statistical findings, showing that transition-based SSGs combined with a 2:2 work-to-rest ratio impose the highest physical demands.

Discussion

The present study examined the effects of transition SSG format and work-to-rest ratio on internal and external training load in university-level soccer players. Three principal findings emerged: (1) work-to-rest ratio significantly elevated HRmean and the percentage of time at 80–89% HRmax under shorter recovery (4:2 and 2:1); (2) the 3v3v3+2 Change format with 2:2 work-to-rest elicited the greatest high-intensity running, peak speed, and neuromuscular demands; and (3) HRmax and %HRmax were unaffected by format or recovery manipulation.

The absence of significant differences in HRmax and %HRmax aligns with the well-established capacity of SSGs to elicit near-maximal cardiac responses regardless of structural manipulation. Köklü et al. (2017) reported that HRmax was unaffected by bout duration in young soccer players, and Farhani et al. (2022) similarly found no format effect on peak HR when varying bout duration and player number, confirming that both transition formats used here are physiologically demanding at the upper end of the cardiovascular spectrum, even under varying recovery durations. In contrast, HRmean and time at 80–89% HRmax were significantly elevated under reduced recovery,

indicating that inter-bout rest duration is the primary driver of sustained cardiovascular strain. Branquinho et al. (2021) similarly found that shorter recovery produced higher HRmean, attributing this to incomplete physiological restoration between bouts, while de Dios-Álvarez et al. (2023) reported that 1-minute recovery increased RPE and attenuated locomotor quality, whereas 2-minute recovery better balanced cardiovascular intensity with movement output. The large effect sizes observed here for HRmean ($\eta^2 p = 0.168$) and the 80%HR zone ($\eta^2 p = 0.162$) are consistent with these reports and indicate that recovery duration can serve as a practical load-adjustment tool without changing the playing format.

Regarding external load, total distance was most strongly influenced by work-to-rest ratio ($\eta^2 p = 0.818$), with the 2:2 condition producing the highest locomotor output across both formats, indicating that recovery duration is the dominant variable governing total movement volume, outweighing the influence of game format. Alcántara et al. (2021) reported comparable findings in youth players, showing that proportionate recovery intervals preserved locomotor output per bout while reducing the rest-to-work ratio progressively diminished total distance; de Dios-Álvarez et al. (2023) further confirmed that a 2-minute recovery optimized the balance between total distance and neuromuscular quality, paralleling the superior locomotor output observed under the 2:2 condition here. The reduced total distance under the 4:2 and 2:1 condition likely reflects fatigue-induced movement suppression when phosphocreatine replenishment and metabolic clearance are insufficient between bouts (Kryściak et al., 2023).

The markedly elevated high-intensity running distance in the 3v3v3+2 Change format under the 2:2 condition (104.67 ± 88.75 m) is the most practically distinctive finding of this study: the spatial transfer requirement completing seven passes before switching zones creates directional running corridors that replicate the locomotor structure of counter-attacking transitions in match play. Asian-Clemente et al. (2023) found that larger transition game formats generated significantly greater high-speed running and peak speed than smaller configurations, attributing this to the spatial demands of positional recovery after each transition, and Asian-Clemente et al. (2024b) similarly demonstrated that transition games produced greater distances above 21 km·h⁻¹ and more high-intensity mechanical actions than official matches. The high inter-individual variability ($SD = 88.75$ m) likely reflects positional differences in transitional movement strategy, consistent with evidence that full backs and strikers cover greater high-speed distances than midfielders during transitions (Bortnik et al., 2022). The near-zero sprint distances across all conditions (0.00– 2.44 m) reflect the recognized limitation of small-format SSGs in generating true sprint velocities above 25 km·h⁻¹, given the pitch-space constraints inherent in 3v3v3+2 designs (Gualtieri et al., 2023).

Acceleration and deceleration counts were highest under the 2:2 condition, with the Change format producing the greatest neuromuscular demands overall. Kryściak et al. (2023) demonstrated that short-bout SSG training elicited significant acid-base balance alterations in youth players, reflecting the repeated acceleration–deceleration cycles that stress anaerobic energy systems and neuromuscular tissue.

The significant reduction in ACC and DEC under the 2:1 condition, despite its short bout duration, demonstrates that excessively compressed recovery impairs explosive mechanical output a dissociation that is practically important, since the 2:1 condition maintained high HRmean yet compromised neuromuscular quality, producing cardiovascular overload without a corresponding mechanical training stimulus. Peak speed followed the same pattern, with the Change 2:2 condition generating the highest values ($6.42 \pm 0.54 \text{ m}\cdot\text{s}^{-1} \approx 23.1 \text{ km}\cdot\text{h}^{-1}$), approaching the high-speed running threshold used in elite match analyses, while the 4:2 condition consistently produced the lowest values across both formats (McLean et al., 2016; Köklü et al., 2017).

From a practical standpoint, when the primary objective is to maximize aerobic intensity and time at high HR zones, the 4:2 or 2:1 work-to-rest conditions are most appropriate; when the goal is to optimize high-speed locomotor output, peak speed, and neuromuscular loading, the 3v3v3+2 Change format with 2:2 work-to-rest is recommended. Farhani et al. (2025) emphasized that SSG bout structure must simultaneously address physiological and technical-tactical objectives, while Branquinho et al. (2021) highlighted that work-to-rest ratio manipulation is an accessible and logistically uncomplicated load-management strategy. Collectively, these findings reinforce the position that work-to-rest ratio deserves priority as a programming parameter alongside pitch size and player number (Alcántara et al., 2021; de Dios-Álvarez et al., 2023; Köklü et al., 2017), and that transition-specific SSG formats provide a complementary tool for overloading high-speed demands that possession-based SSGs may systematically underexpose.

Limitations

This study has several limitations that should be considered when interpreting the findings. First, although the sample size ($n = 18$) exceeded the a priori target established via G*Power (16 participants), the sample remained relatively small and comprised a single cohort, which may still limit the detection of smaller effects for some variables. Second, participants were exclusively male university-level players; the findings may not generalize to female players, youth athletes, or players competing at higher (professional/elite) or lower competitive levels. Third, although the order of the eight experimental conditions was fully randomized for each participant to minimize order effects, cumulative fatigue across repeated sessions cannot be entirely excluded. Fourth, some GNSS-derived external-load variables, particularly high-intensity running distance (SD up to 88.75 m) and sprint distance, showed high inter-individual variability, likely reflecting positional differences in movement behaviour, and should be interpreted with caution. Future studies should include larger and more diverse samples, including female and multi-level cohorts, to confirm the generalizability of these findings.

Conclusions

The present study demonstrated that both transition game format and work-to-rest ratio significantly influenced training load responses during small-sided soccer games. Shorter recovery conditions (4:2 and 2:1) increased internal

load, as evidenced by higher HRmean values and greater time in high-intensity heart rate zones, indicating elevated accumulated cardiovascular stress. In contrast, the 2:2 work-to-rest ratio elicited the highest external load overall: total distance was greatest under the 3v3v3+2 (non-Change) format at 2:2, whereas the 3v3v3+2 Change format combined with 2:2 produced the greatest high-intensity running, peak speed, and neuromuscular demands (accelerations and decelerations). These findings suggest that work-to-rest ratio primarily modulated internal load, while transition-based game formats were more effective in increasing external load, especially high-speed and explosive actions; peak heart rate responses remained stable across all conditions, indicating that SSGs consistently provide a near-maximal cardiovascular stimulus regardless of structural manipulation.

This study contributes novel evidence on the combined effects of transition game formats and work-to-rest ratios, an area that has been insufficiently explored. The results offer practical implications for coaches: shorter recovery durations can be used to increase aerobic and cardiovascular stress, whereas transition formats combined with balanced recovery (2:2) are more suitable for developing high-intensity locomotor and neuromuscular performance. Future research should investigate the long-term adaptations to these training configurations, as well as their effects across different playing levels, positional roles, and competitive contexts, to further optimize the design of soccer-specific conditioning programs.

Funding

This research was funded by Kasem Bundit University (Academic Year 2025), Project Approval No. R005/69P.

Acknowledgments

The authors would like to thank the Faculty of Sport Science, Kasem Bundit University, Bangkok, Thailand, and the Faculty of Science, Chandrakasem Rajabhat University, Bangkok, Thailand, for their support and contribution to this research. The authors also express their sincere gratitude to the soccer players of Kasem Bundit University for their participation, commitment, and cooperation throughout the study.

Ethics Approval

This study was approved by the Ethics Committee of Kasem Bundit University, Thailand (KBU-HREC 009/69), and was conducted in accordance with the Declaration of Helsinki.

Informed Consent Statement

All participants were informed about the study procedures prior to participation, and written informed consent was obtained from all participants.

Data Availability Statement

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

AI Transparency Statement

The authors declare that artificial intelligence (AI)-assisted tools were used exclusively to improve the linguistic quality, grammar, readability, and formatting of the manuscript. AI tools were not used to generate, analyze, interpret, or manipulate the research data, statistical analyses, results, or scientific conclusions.

Conflicts of Interest

The authors declare no conflicts of interest.

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Оцінювання впливу формату перехідних ігор неповними складами та співвідношення режимів вправ і відпочинку на тренувальне навантаження у футболістів

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Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 10 с., 4 табл., 3 рис., 30 джерел.

Обґрунтування. Ігри неповними складами (ІНС) широко використовуються у тренувальному процесі футболістів для одночасного розвитку фізичних та фізіологічних показників. Проте специфічні формати перехідних ігор неповними складами у поєднанні з маніпулюванням співвідношення режимів вправ і відпочинку можуть додатково впливати на тренувальне навантаження, хоча їхній ефект взаємодії залишається малодослідженим.

Мета дослідження. Мета цього дослідження полягала у вивченні впливу формату перехідних ігор неповними складами та співвідношення режимів вправ і відпочинку на внутрішнє та зовнішнє тренувальне навантаження футболістів університетських команд.

Матеріали та методи. У дослідженні взяли участь 18 футболістів чоловічої статі університетських команд. Було застосовано два формати перехідних ігор (3v3v3+2 та 3v3v3+2 зміна) та чотири режими співвідношення вправ і відпочинку (4:4, 4:2, 2:2 та 2:1). Внутрішнє навантаження оцінювали за показниками частоти серцевих скорочень (ЧСС), а зовнішнє навантаження вимірювали за допомогою пристроїв Глобальної навігаційної супутникової системи (GNSS). Для аналізу даних використовували двофакторний дисперсійний аналіз із повторними вимірюваннями.

Результати. Як співвідношення режимів вправ і відпочинку, так і формат гри суттєво впливали на внутрішнє навантаження: вища середня частота серцевих скорочень (ЧСС) та більша кількість часу, проведеного вище порогу 80% від

ЧСС, спостерігалися за умов коротшого відпочинку (4:2), а також вища середня ЧСС зафіксована загалом для формату без змін. Показники зовнішнього навантаження продемонстрували значні головні ефекти та ефекти взаємодії: співвідношення 2:2 забезпечило найбільшу загальну дистанцію, кількість прискорень та сповільнень, тоді як формат 3v3v3+2 зі зміною у поєднанні зі співвідношенням 2:2 викликав найвищу інтенсивність бігу та пікову швидкість. Максимальна ЧСС продемонструвала значну взаємодію факторів Формат × Вправи-Відпочинок, хоча жодне індивідуальне попарне порівняння умов не залишилося статистично значущим після застосування поправки Бонферроні.

Висновки. Отримані результати свідчать про те, що поєднання формату перехідних ігор із належним співвідношенням режимів вправ і відпочинку можна використовувати як ефективну стратегію для регулювання тренувальних навантажень у футболістів.

Ключові слова: зовнішнє навантаження, внутрішнє навантаження, ігри неповними складами, футбол, тренувальне навантаження.

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Cite this article as: Choosungnoen, P., Pavilas, C., Riansoi, Y., & Kaewprag, S. (2026). Assessing the Effects of Transition Small-Sided Game Format and Work-to-Rest Ratio on Training Load in Soccer Players. *Physical Education Theory and Methodology*, 26(5), 956-965. <https://doi.org/10.17309/tmfv.2026.5.13>

Received: 17.08.2026. Accepted: 30.08.2026. Published: 28.09.2026

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