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Benefits of Native-Local games intervention based on the TGFU-GS pedagogical models for motor proficiency and cognitive ability in children

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Abstract

Background: Both the Teaching Game for Understanding (TGFU) and Game Sense (GS) have been connected to the theory of situated learning, which is a game-centered curricular model. Therefore, it is worth exploring the integration of TGFU with GS (TGFU-GS) model in PE courses, and whether the hybrid TGFU-GS model can achieve better learning effects for students than the TGFU and GS model alone.

Aim: This study aimed to assess the impact of a four-month Native-Local games intervention, based on the TGFU -GS model, on children's motor proficiency and cognitive ability.

Martials and Methods: This study used a quasi-experimental with a pretest-posttest design to compare different learning effects between the experimental group (TGFU-GS) and the control group (Traditional). Two groups of children engaged in 12 weeks of TGFU-GS (n=13, age=10.78±0.93 years) or the traditional (n=14, age=10.63±0.72 years) approach. The Bruininks–Oseretsky test of motor proficiency and the Simon effect test of cognitive ability were utilized.

Results: The results of a mixed ANOVA showed that there was a significant difference between pre-test and post-test in the experimental group. In the TGFU-GS group significantly greater improvements in both motor proficiency and cognitive ability compared to the traditional group ($p < 0.05$). Also, TGFU-GS approach led to improvements on motor proficiency (p=0/0001) and cognitive ability (p=0.0001) than the traditional approach.

Conclusion: It is suggested that the hybrid TGFU -GS model could be implemented effectively in the physical education curriculum.

Keywords: traditional games, nonlinear approaches, motor skills, cognitive capability.

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1. Introduction

The latest trends in the field of education indicate a change in educational approaches and teaching methods while trying to increase student participation and improve the learning process (1). In recent years, there has been considerable interest in the evolution of physical education (PE) teaching practice from a traditional and linear approach to a new and non-linear approach (2). Kirk (3) summarized traditional PE pedagogy as "characterized by relatively short units of activity; an overwhelming focus on technique development; a lack of accountability for learning and little progression of learning; and the almost exclusive use of a directive teaching style". This is in stark contrast to productive styles which allow students to individually explore problems and make decisions while permitting the new knowledge and movement solutions to emerge. One of the productive styles in recent years is the teaching Games For Understanding (TGFU) approach, proposed by motor learning researchers as a suitable teaching method to replace traditional teaching technics to support the development of students' fundamental skills (4). Teaching Games for Understanding means "how to teach students to learn and understand through games" (5, 6). It emphasizes the concept of appreciation in the game because the concept involves aspects of tactical awareness as the basis for decision-making while playing (7, 8). Cocca et al. (4) assessed the changes in students' physical fitness after a six-month TGFU-based program with elementary school children and concluded that TGFU could be a valid alternative to the traditional methodologies, not only when a PE unit aims to stimulate the cognitive domain, but also for the development of physical fitness attributes that may help pupils develop comprehensively manner (9).

One of the other productive styles in motor learning, somewhat opposite of the traditional ones, is the Game Sense (GS) approach. This approach was introduced to the Australian sports coaching literature during the 1990s, emerging from Thorpe's collaboration with the Australian Sports Commission (ASC) between 1994 and 1998 as the Australian version of Teaching Games (Sport) for Better Understanding (10). A GS approach, as an example of a game-based approach for games and sport teaching in PE, arguably facilitates deeper student learning by teaching "first" for understanding and thus meaningful game participation. Therefore, concerning the cognitive and emotional dimensions of learning, a GS approach can be looked at as potentially more meaningful for student learning than a "traditional" approach (11). Williams and pill (12) explored the opportunity for coach/teacher learning within the context of a unit of work taught in a primary school while focusing on an Australian local game taught using a game sense approach. In this study, the GS approach was emphasized as an effective learning opportunity for students. Therefore, one example of an innovation to enhance sports teaching and learning is the

Teaching Games for Understanding-Game Sense approach (13).

Another productive style based on new approaches is play. As a powerful and important activity, play is an essential part of early years' education and development. According to education researchers, it is a sturdy mediator of learning various skills throughout a person's life (14). The attention of all human societies to the child's need to play in different countries has led to the emergence of native-local games for centuries. One of the important features of native-local games is the use of tools and facilities of the place of residence without a need for special equipment. These games are part of the cultural heritage of every nation and include various movements, contributing to the learning and development of basic skills (15). Besides, they can be opted for by a large and wide group of people of different ages, playing with simple facilities available in the community and without any restrictions (16), with the utmost freedom and without being bound to place, time, and cumbersome tools (17).

Motor skills are crucially important integral elements for mastering complex movements, but they are also necessary components for the building of movements required for involvement in sports (18), consisting of control over objects (throwing or catching the ball), fundamental locomotor movements (running, jumping, skipping), as well as of stability, i.e., balance (19). Proficiency in motor skills is necessary for playing different types of games and having a physical, social, and mental health (20). Motor skills are divided into gross and fine motor skills (21). Gross motor skills are the ability to use major muscle groups to perform regular joint movements, while fine motor skills are regulated by small muscles (22). On the other hand, cognitive ability refers to the brain's natural skills used for both simple and complex tasks. Many models have attempted to explain the factors that predict cognitive abilities in children. Contrary to older models that highlighted the role of genetic factors in the development of cognitive skills (23), emerging ecological models suggest that cognitive abilities are developed within a combination of multilevel contextual and biological processes (24). The underlying argument of the ecological models is that during critical periods, consistent environmental experiences impact the development of related circuity (prefrontal cortex) underpinning high-level cognitive skills (25). According to this model, children are mainly dependent on their parents and teachers for providing opportunities to develop cognitive abilities through high-quality interactions (26, 27). So, one of the primary responsibilities of teachers and parents is to provide special backgrounds and educational conditions.

Despite the many advantages mentioned for the educational approaches (TGFU and GS) have provided, an approach that is useful for covering all educational content or contexts has not yet been found (8, 28). This limitation is due to the

necessity of combining several parts or important elements of these approaches, which creates a term the "hybrid of educational approaches" (28). Also, it has been suggested that the hybrid of these models enables a wider and deeper range of learning than what can be achieved through the use of a more traditional teacher-centered educational approach, as well as each model in its form (29). As a result, hybridization can be an effective mechanism to achieve higher-quality learning outcomes in physical education curricula (30, 31).

Both TGFU and GS models are important models that transformed from teacher-centered to student-centered learning in physical education (32). The theory of situated learning has been connected to TGFU and GS (33). Situated learning theory, first initiated by Lave and Wenger (1991), states the skills and knowledge gained as a result of participating in a community of practice. TGFU and GS could provide more meaningful and purposeful content in authentic learning situations than other approaches (34). The GS model has a structured season, but it lacks effective game strategies to improve student game performance. TGFU can improve tactical strategies, making up for the shortcomings of the GS model because TGFU connects tactics with skills in the learning context (35). Therefore, TGFU is integrated with the GS program to determine whether it will improve students' motor proficiency and cognitive abilities. It is worth implementing the TGFU -GS hybrid model into PE lessons to obtain the results of empirical research.

2. Methods and Materials

2.1. Participation

This research was semi-experimental and minimum number of samples was 13 people using G*power software and taking into account statistical power of 0.8, effect size of 0.3 and confidence interval of 0.95. Therefore, two groups of 27 children aged 10-11 (M= 10.70, SD=0.82) years with a pretest-posttest design, conducted by convenience sampling in Tabriz, Iran. The first group consisted of 13 girls, named the hybrid of the TGFU-GS group. The second group included 14 girls, named the traditional teaching group. At first, a letter of consent was received from parents for their children's participation in the research, and all participants voluntarily took part in the present study. Additionally, no behavioral, motor, or cognitive problems were reported for any of the children. The present study was conducted in a school setting where physical education teachers traditionally used direct instruction. Two physical education teachers with a range of 10 to 20 years of teaching experience in the elementary school participated in this study. one person in the TGFU-GS unit, in the form of native-local games, and another person applied direct instructions.

The teacher of TGFU-GS unit had previously completed special courses, which include:

The TGFU-GS Approach:

This includes understanding the core principles of TGFU-GS, such as focusing on tactical awareness and decision-making in game-like situations, rather than solely on technical skills.

Game Categories:

Teachers need to be knowledgeable about the four main game categories (net/court, invasion, striking/fielding, and target games) and how to analyze games within and across these categories.

Questioning Techniques:

Effective use of questioning is a key component of TGFU-GS, and teachers need training in how to pose questions that encourage students to think critically about game strategies and tactics, according to the Journal of Physical Education and Sport.

Lesson Planning and Implementation:

Teachers need to be able to plan and deliver TGFU-GS lessons that incorporate game play, questioning, and skill practice in a way that is student-centered and developmentally appropriate.

Safety:

Training in safety protocols and procedures is also essential for any physical education setting.

2.2. Instrument

The Bruininks–Oseretsky test of motor proficiency the third Edition (BOTMP-2) was used to assess the children's gross and fine motor skills. The BOTMP consists of eight subtests (running speed and agility, balance, bilateral coordination, strength, upper-limb coordination, response speed, visual–motor control, and upper-limb speed and dexterity), with a total of 46 separate items that provide a comprehensive index of motor proficiency, as well as separate measures of both gross and fine motor skills. Four of these subtests combine to form the gross motor composite score, and three subtests combine to form the fine motor composite score. These seven subtests, together with a subtest of upper-limb coordination, form the battery composite score (36). The BOTMP provides age-norm and composite scores, based on a T-score with a mean of 50 (SD = 10). This test has wide clinical and educational acceptance because it measures the skills important to children's development, and it is perceived to have good psychometric properties. Moreover, the validity and reliability coefficients of this scale have been approved (37).

The Simon-effect test using Coglab software was used as a measure of inhibitory control, i.e., a measure of individuals' ability to inhibit irrelevant stimuli, one of the functions of inhibitory control (38). This version of the Simon task consists of responding to a stimulus color with a correspondent key, ignoring its location. utilized to assess the children's cognitive ability (39). In this test, first, a window covering the entire screen will appear, along with which a window of instructions will appear. A fixed dot will appear in the middle of the screen. After a short time (less than a second), a green or red square is displayed to the right or left of the fixed point. The task is to press the V key when the green square appears and the M key when the red

square appears. After each attempt, feedback will be received on whether the answer is right or wrong and on the reaction time in the thousandth of a second. There are at least 100 attempts in this test. If an error occurs, the attempt will be repeated in the continuation of the test. Finally, the test window will be closed automatically and a new window will appear displaying the data of the subject in the form of tables and graphs and providing explanations about the test and the results (40).

2.3. Procedure

The research design included three stages before the intervention, intervention, and post-intervention. Before conducting the research, the author approached PE teachers to discuss the purpose of the study. Afterward, the teachers were informed about the background of the study and the nonlinear approaches used, emphasizing the fact that their participation was voluntary. In the pre-intervention phase, the subjects were familiarized with Native-local games and research stages in one week, practice approaches were discussed separately, and tasks and goals were explained. Also, before the intervention, and during a period of sevral sessions, the Native-Local game was taught to the teachers using the hybrid of the two approaches (TGFU-GS). Then, the dependent variables of the research were evaluated in the pre-test using the Bruininks–Oseretsky test of motor proficiency and cognitive psychology tests of CagLab software, which measure the subjects' motor proficiency and cognitive ability, respectively. In the intervention phase, the independent variables of the research were implemented with native-local game protocols based on a hybrid of TGFU and GS approaches and traditional practice for 12 weeks, three sessions each week, and one hour each session separately in each group (Table1: training protocol for TGFU-GS and Traditional groups). After completing the training protocol, the motor proficiency and cognitive ability of the students were measured in the post-test stage with the same instrument as the pre-test.

2.4. Statistic

Using IBM Corp, released in 2015; IBM SPSS Statistics for Windows, Version 21.0; and Armonk, NY: IBM Corp, the mean, standard deviation (SD), and figures were explored and illustrated. Missing data, normality of the data distribution, and group differences at the pre-test stage were checked. The data were evaluated in terms of normal distribution using the Shapiro–Wilk test. A mixed ANOVA analysis of variance was used to examine the research hypotheses. For all analyses, the level of significance was set at alpha < 0.05.

3. Results

Descriptive statistics of motor proficiency and its subscales, gross and fine motor skill scores, and cognitive ability scores are presented in table 2.

Table 1. Groups training protocol

Types of games in each approach		
weeks	TGFU-GS	Traditional
1	Middle game, explaining why the game is played and having a question and answer session	Middle game, direct teacher instructions
2	Lily's game, tactical awareness and answering questions and adjusting the game to suit the physical level of the individuals	Lily's game, emphasizing correct repetition of skills
3	Capture the Flag game, presenting tactics and questions and discussion	Capture the Flag game, explanation of how to play and practice the game
4	A game of needle and thread, emphasizing quick decision-making and stimulating thinking and discussion.	Needle and thread game, teaching the game by the teacher and in a structured way
5	Kabaddi game, presenting tactical awareness and why, and questions and answers	Kabaddi game, learning how to play the game
6	Hop Hop Game, providing a solution for speed, answering questions and making people think	Hop Hop Game, teacher explains how to play the game
7	Cockfighting game, explanation of why and strategies for playing the game	Cockfighting, direct instructions from the teacher and its implementation by the student
8	High-altitude game, presenting some tactical solutions and questions and answers	High-altitude game, teaching skills and doing them
9	Rope game, explaining why the game is played and involving people in explaining the game	Rope game, explaining how the game is played by the teacher
10	The game of Kolhapuran, tactical awareness and engagement with questions and answers	The game of Kolhapuran, traditional teaching by the teacher
11	Marble game, explaining why and asking students how to succeed	Marble game, explaining how to play the game and having students repeat the skill
12	The game of Elk and Delk, tactical awareness and asking questions	The game of Elk and Delk, explaining how to play the game and practicing it

Table 2. Descriptive findings of research variables

Groups	variables	Pre-test		Post-test	
		Mean	SD	Mean	SD
TGFU-GS	Gross skill	41.46	6.39	79.15	9.68
	Fine skill	40.31	6.76	72.61	5.88
	motor proficiency	93.08	10.71	169.54	14.96
	Cognitive ability	412.03	129.68	793.98	110.10
Traditional	Gross skill	38.43	4.45	41.85	6.32
	Fine skill	33.86	5.07	35.21	5.77
	motor proficiency	78.79	8.47	87.86	11.57
	Cognitive ability	398.18	179.63	401.64	187.04

As mentioned, the Shapiro-Wilk test was used to examine the normality of the data distribution in the pre-test scores. The results showed that, given that the significance values obtained were greater than 0.05, the assumption of normality of the data distribution was confirmed in all variables ($P < 0.05$); after confirming the normality of the data, one-way ANOVA was used to examine the presence or absence of differences in the pre-test. Given the lack of significant differences in the pre-tests in the dependent variables of the study, a Mixed ANOVA was used to examine the differences between the pre-test and post-test in both the TGFU-GS and traditional groups for motor proficiency and cognitive ability. According to the results of the Lone test and Box

test, the assumption of equality of variances and covariances was also observed. Figure 1 shows a chart of the trend of changes in the dependent variables of the study in the pre-test and post-test in each group.

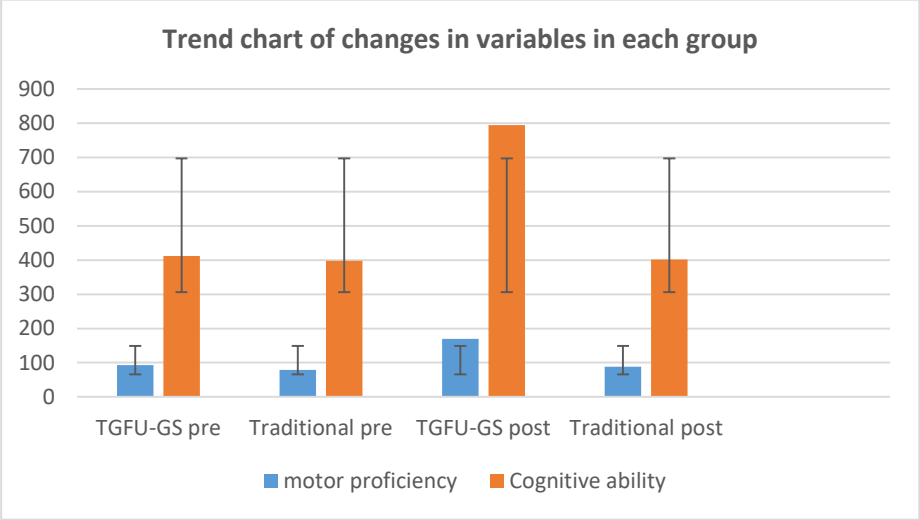

Figure 1. Trend chart of changes in variables in each group

Motor Proficiency

According to the results of one-way ANOVA, no significant difference was obtained between the two groups in the pre-test of motor proficiency. The results obtained from the Mix ANOVA showed that the main effect of time (pre-test and post-test ($F_{(1,25)}$= 2722.99, $p<0.001$, $\eta^2=0.99$), the main effect of group (TGFU-GS and Traditional) ($F_{(1,25)}=118.53$, $p<0.001$, $\eta^2=0.83$), the main effect of motor proficiency ($F_{(2,24)}=536.50$, $p<0.001$, $\eta^2=0.98$), the interaction effect between group and time ($F_{(1,25)}=262.48$, $p<0.001$, $\eta^2=0.91$), the interactive effect of motor proficiency and time ($F_{(2,24)}=640.66$, $p<0.001$, $\eta^2=0.98$), the interactive effect between group and motor proficiency ($F_{(2,24)}=121.71$, $p<0.001$, $\eta^2=0.91$), and finally the interaction effect of three factors, namely time in the group on motor proficiency ($F_{(2,24)}=197.29$, $p<0.001$, $\eta^2=0.94$), are significant. In the following, considering the significance of the interaction effect of time, group, and motor proficiency in Table 3, their effects were examined.

Table 3. Pairwise comparison of groups in the pre-test and post-test of motor proficiency

group	variables	Mean Difference (TGFU/GS – Traditional)	Std. Error	P
TGFU-GS	Gross skill	37.29	3.12	0.000*
	Fine skill	37.40	2.24	0.000*
	motor proficiency	81.68	5.12	0.000*
Traditional	Gross skill	3.03	2.13	0.17
	Fine skill	6.45	2.31	0.10
	motor proficiency	10.29	3.73	0.11

* $p \leq 0.05$.

The results of the pairwise comparison of the groups in the TGFU-GS these findings showed: Gross skill ($F_{(1,25)}$=272.38, p<0.001, η^2=0.92), fine skill ($F_{(1,25)}$=51.99, p<0.001, η^2=0.67), and motor proficiency ($F_{(1,25)}$=2204.31, p<0.001, η^2=0.99), And the pairwise comparison of the groups for the traditional group includes the following results: Gross skill ($F_{(1,25)}$=3.12, p<0.089, η^2=0.11), fine skill ($F_{(1,25)}$=2.81, p<0.073, η^2=0.09), and motor proficiency ($F_{(1,25)}$=3.07.31, p<0.09, η^2=0.08). According to the results, it can be said that the TGFU-GS group achieved the highest score in motor proficiency compared to the traditional group.

Cognitive Ability

According to the results of one-way ANOVA, no significant difference was obtained between the two groups in the pre-test of motor proficiency. The results obtained from the Mix ANOVA showed that the main effect of time (pre-test and post-test ($F_{(1,25)}$=40.03, p<0.001, η^2=0.62), the main effect of group (TGFU-GS and Traditional) ($F_{(1,25)}$=430.34, p<0.001, η^2=0.94), the interaction effect between group and time ($F_{(1,25)}$=41.98, p<0.001, η^2=0.63) are significant. In the following, considering the significance of the interaction effect of time and group in Table 4 their effects were examined.

Table 4. Pairwise comparison of groups in the pre-test and post-test of cognitive ability

group	variable	Mean Difference (TGFU/GS – Traditional)	Std. Error	P
TGFU-GS	Cognitive ability	233.90	26.30	0.000*
Traditional	Cognitive ability	-2.79	25.35	0.91

* $p \leq 0.05$.

The results of the pairwise comparison of the groups in the TGFU-GS these findings showed: Cognitive ability ($F_{(1,25)}$=79.07, p<0.001, η^2=0.76), And the pairwise comparison of the groups for the traditional group includes the following results: Cognitive ability ($F_{(1,25)}$=0.012, p<0.91, η^2=0.001). According to the results, it can be said that the TGFU-GS group achieved the highest score in Cognitive ability compared to the traditional group.

4. Discussion

The purposes of the study were to investigate the effect of a Native-Local games intervention based on the TGFU-GS unit, in comparison to traditional teaching, on students' motor proficiency and cognitive ability. The results of this study showed that the TGFU-GS pedagogy of the experimental group had more positive learning effects on students' motor proficiency, (including the gross and fine motor skills) and cognitive ability than traditional pedagogy of the control group. Linking findings to previous research, the TGFU-GS pedagogy could enhance game performance (32). It is also consistent with previous studies; Gómez Buendía et al. (2022) showed that the hybrid TGFU-GS pedagogy could generate positive effects on students' sports

manship (41). Gil-Arias et al.(2017) presented that the hybrid TGfU-GS pedagogy with diverse features such as manipulation of equipment or rules of a game, providing children with the freedom to explore an environment, modify individual, task and environmental constraints afford different play chances and increase the opportunity to improve motor skills (31).

In the situated learning theoretical framework for teaching in PE, both the TGFU and GS pedagogies are game-centered approaches based on situated learning theory (33). The experimental group integrated the TGFU pedagogy into the GS pedagogy. The TGFU pedagogy emphasized that both game strategy and skill execution are important in learning contexts. In the TGFU pedagogy, students make decisions and execute skills to develop good game performance. Therefore, PE teachers need to provide authentic game situations to develop students' sport competence, including game strategies and motor skills (42). The GS pedagogy indicates an ecological understanding of skill learning, describing skill as a function of tactical and technical competency (43).

In a hybrid TGFU-GS pedagogy, in terms of motor proficiency, students could learn more tactical awareness and skill execution in authentic situations. This meant that students would pay attention to their own learning to improve their game performance. In past studies, TGFU was integrated with the GS pedagogy in a hybrid model that enhanced game performance, and the results were similar to those of past studies (44, 45). TGFU-GS pedagogy can enable students to learn game strategies and skill execution across game seasons in the GS model. Students continue to learn tactical strategies and practice skill execution over a season so that they can enhance their game performance over time. The TGFU pedagogy guides students to appreciate games, understand tactical awareness, make decisions, and execute skills, ultimately achieving good game performance. TGFU pedagogy also emphasizes tactical understanding and skill execution. Past studies have shown that TGFU can significantly improve students' game performance (46) (47). The results of the study were consistent with the research hypothesis and verified Farias et al. (2015) suggestion that a hybrid sport education-invasion game competence model could promote improvements in students' game performance and understanding. The GS model provided an authentic learning environment, and the TGFU provided learning tasks focused on tactical content and skill execution. Some studies have indicated that the GS model can improve learning effects in game performance. The results also verify Farias (32) finding that the GS model can significantly improve students' game performance and Ghorbanzadeh (2025) finding that TGFU can improve students' game performance (48). Therefore, integrating TGFU with GS can enable students to improve motor proficiency in the hybrid TGFU-GS pedagogy. Li et al. (2018) indicated that situated game teaching has the potential to enhance curricular

development and teach tactical decision-making in games in PE (33).

In terms of Cognitive ability, both the TGFU and GS pedagogies can promote learning enjoyment in PE lessons. Through reflective thinking and problem-solving strategies in the TGFU model, students gain team cohesion through the season of the GS model. The Russian psychologist Vygotsky (49) theorized that interaction with others has a great influence on cognitive ability. He argued that children can accomplish larger amounts of cognitive improvement through social interaction, but Piaget failed to acknowledge this influence (50). Piaget established his cognitive development theory based on children's dealing with physical objects, however, Vygotsky believed that a child's mind develops when they interact with other people's minds (51). This interaction usually happens through play. During play, a non-linear approach, children can learn how to work together, adapt to different situations, experiment, explore and solve problems, and construct meaning, contributing to the development of the cognitive ability of children (52). Also in TGFU-GS non-linear approach improving cognitive ability occurs through the following (1) the need to develop a sense of depth about a concept; (2) an environment based on inquiry; (3) changing one's frame of reference through experimentation; and (4) implementation of cooperative and individual learning (53). Indeed, the basic concept of TGFU-GS is to develop students' cognitive, motor and social skills in sports and games based on problem-solving methods in decision-making (54). Storey and Butler (55) demonstrated that TGFU and GS begin with a simple game or activity progressively becoming more tactically complex with the underlying purpose of learning to maximize appreciation, enjoyment, cognitive development, and physical growth to encourage participation in future games, activities, and sports. The findings of this study are also congruent with those of a study by Light, Reid & Harvey (56, 57), which showed that TGFU and GS have similar theoretical underpinnings supporting the use of either approach to developing holistic learning e.g. cognition, motor development, and social learning. Also, Stolz and pill (53) investigated a narrative approach to explore TGFU-GS and found that the TGFU-GS approach is a challenge as the PE teacher must not only be knowledgeable about the game but also possess the ability to be able to make appropriate cognitive demands on learners to encourage learners to be active in the development of game understanding. Besides, some studies have indicated improved cognitive capacity in the area of tactical awareness and decision-making resulting from the TGFU and GS approach (58-60). Therefore, integrating TGFU into an GS model enables students to obtain more Cognitive ability from PE lessons.

Limitations and Suggestions

One of the strengths of the present study was the semi-experimental research method, but there are several limitations. The first limitations of this study are the short intervention time in which the

educational program was implemented since teachers new to the methodology expressed the little adaptation period they had to be able to apply it. Second, given the convenience and small sample size, results should be interpreted with caution. Future studies with representative and larger sample sizes at different schools and with more PE teachers could help to refute these findings. Third, the present study only examined the effects of a hybrid TGFU-GS teaching unit on variables related to motor and cognitive ability. Examining variables related to social ability could be a new and interesting avenue of research. Fourth, only one hybrid TGFU-GS teaching unit was developed in the current study. Consequently, it would be valuable to implement other consecutive hybrid TGFU-GS teaching units with different characteristics (e.g., individual sports, outdoor and adventurous activities, artistic expression activities, etc.) and gender stereotypes (e.g., football, dance, skipping rope, rugby, etc.). Fifth, Conducting more research in this area can evaluate the effectiveness of practical recommendations related to learning and identify more issues surrounding practical challenges related to the design and delivery of authentic non-linear learning in the school environment. Finally, it is suggested that a guidebook of the teaching plan be prepared based on the examined approaches and presented to the General Directorate of Education.

5. Conclusion

The findings of the analyses highlight the significance of challenging non-linear pedagogy for motor proficiency and cognitive ability. Unfortunately, the traditional physical education teaching has emphasized motor skill development and fitness for games and sports. TGFU-GS presents an alternative adjustment of emphasis to thinking-decision making, fitness, and motor skill development as combining to express game competency. Kinchin and O'Sullivan [61] wrote that this change in emphasis moves teaching from 'teacher centered' to 'learner centered' with an emphasis on "teaching for understanding". As the PE curriculum in Iran faces further time constraints, PE teachers need to employ the most effective pedagogical approach, which allows for improving students' motor and cognitive abilities in PE. Therefore, motor proficiency is stimulated and achieved through appropriate challenges, and following improved motor skills, multiple and cognitive experiences become apparent. Overall, TGFU-GS may not represent a 'rethinking', 'new approach' or 'paradigm shift' in thinking about game and sport teaching but rather a refining and further development of existing practices. Thus, this issue should be explored in future research.

Limitations

The present study was conducted on high school female basketball athletes with DKV and investigated the short-term effects of basketball SMs on landing technique and DKV. Therefore, its results cannot be generalized to other age

groups, semi-professional and elite levels, and male basketball players because landing technique and types of neuromuscular impairments vary across populations.

Conflict of interest

The authors declared no conflicts of interest.

Authors' contributions

Conceptualization, H.M. and M.K.; methodology, H.M.; software, H.M.; formal analysis, H.M. and M.K.; funding acquisition, H.M.; investigation, M.H. and M.K.; resources M.H. and M.K.; data curation, M.K.; writing—original draft preparation, H.M. and M.K.; visualization, H.M. and M.K.; supervision, H.M.; writing—review and editing, H.M. and M.K. All authors have read and agreed to the published version of the manuscript.

Ethical considerations

The author has completely considered ethical issues, including informed consent, plagiarism, data fabrication, misconduct, and/or falsification, double publication and/or redundancy, submission, etc.

IR/SSRI.REC.1401.1366

Data availability

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

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