Int. J. Sport Psychol., 2012; 43: 420-437
doi: 10.7352/IJSP 2012.43.420

Learning opportunities in 3 on 3 versus 5 on 5 basketball game play: An application of nonlinear pedagogy

ISABEL B. TALLIR*, RENAAT PHILIPPAERTS, MARTIN VALCKE**, ELIANE MUSCH*, MATTHIEU LENOIR*

Ghent University, Belgium
(*)Department of Movement and Sports Sciences,
(**)Department of Educational Studies

This study investigates the differential learning opportunities in 5 on 5 versus 3 on 3 basketball game play. Video-analysis of the game performance of thirty basketball players (10-11 years) resulted in significantly higher scores on all game performance components (GPC's: cognitive decision making component (DM), motor skill execution efficiency (MSEfficiency) and motor skill execution efficacy (MSEfficacy) component), indicating more learning opportunities during 3 on 3 game play. The actual game performance level, showed only significantly higher scores for the percentage of positive decisions for cutting actions in the 5 on 5 condition. Future research is needed to indicate to what extent learning results are easier or faster attained when using small sided games, based on the nonlinear pedagogy framework, and second which is the optimal game play situation to assess game performance, and this for players of a different game performance level or for different stages.

KEY WORDS: Game Performance, Motor skill acquisition, Small-sided games, Task constraints.

Introduction

The constraints-led dynamical system approach, building further on the information-movement coupling principle, is promoted as a framework for understanding the process of motor skill acquisition in sport and exercise (Davids, Button, & Bennett., 2008; Araújo, Davids, Bennett, Button, & Chapman, 2004). This constraints-led approach views influential factors within the learning environment as constraints that guide the acquisition of movement coordination and control (Newell, 1986, 1996). Modelled as

Correspondence to: Isabel B. Tallir, Department of Movement and Sports Sciences, Ghent University, Watersportlaan 2, B-9000 Gent, Belgium. E-mail: isabel.tallir@ugent.be

dynamical systems, team sports display characteristics of complexity due to the potential for interactions that emerge between performers over time. The decisions and the actions of a single player become dependent on what neighboring players (either teammates or opponents) are doing and on the immediate events prior to a sub-phase emerging. This contextual dependence in behaviour signifies that player interactions are not deterministic (entirely predictable), nor completely random (entirely variable). Consequently, invasion game play can be characterized as a nonlinear dynamical system (Chow et al., 2006) since it is composed of many interacting parts (e.g., players, ball, referees, court dimensions) (e.g., Gréhaigne, Bouthier, & David, 1997; McGarry et al., 2002).

Based on the influences of motor learning frameworks on motor skill acquisition and decision-making nonlinear pedagogy was presented by Chow and colleagues (2006) as a methodology for games teaching, capturing how phenomena such as movement variability, self-organization, emergent decision making, and symmetry-breaking occur as a consequence of interactions between agent-agent and agent-environment constraints. Nonlinear pedagogy highlights the interactive role that key constraints (i.e., performer, task and environmental) play in learning contexts to shape emergent movement behaviors which arise during practice (Chow et al., 2006, 2007; Davids, et al., 2008). Since sports are dynamic non-linear systems and as such, sport skill learning should also be non- linear (Chow et al., 2007). This can be achieved by pedagogical manipulation of three elements; game constraints (such as changing game rules), performer constraints (such as how the performer is permitted to move), and environmental constraints (such as changing spaces or equipment). Chow et al. (2009) noted that one of the strengths of tactical instructional approaches, such as Teaching Games for Understanding (TGfU) (Griffin & Butler, 2005), is that it enables learners to practice in a managed environment with all key information sources present, so that perceptual and action processes in learners can become tightly coupled during practice. The lack of variability in the traditional "closed" training drills reduces the opportunity for players to learn how to adapt movement solutions to changing environmental demands. While closed drills may provide a simplified environment that allows players to execute skills with increased precision and reduced error, modified games provide players with an opportunity to better calibrate the execution of the skill with relevant and reliable perceptual variables, such as the locations of defenders relative to teammates (Passos, Araújo, Davids, & Shuttleworth, 2008). Therefore, unlike the traditional approaches, tactical instructional approaches advocate a student-centered emphasis for learning tactics and skills in modified games (e.g., Griffin, Butler, Lombardo & Nastasi, 2003). This is an perfect illustration of the motor learning principle of information-movement coupling which proposes that the motor learning of the skills needed in games should involve the process of task simplification, rather than traditional methods of part-task decomposition (Davids et al., 2008). Task simplification refers to a process whereby scaled-down versions of tasks are created in practice and performed by learners to simplify the process of information pick-up and coupling to movement patterns. In these scaled-down modified game contexts, important information-movement links are maintained in practice and are not disrupted in practice task design. This implies that the information available to be actively explored by players during practice must represent the same task and environmental constraints that exist during performance. Otherwise, the information-movement couplings that emerge during practice will be attuned to perceptual variables different from those available during performance or in other words decision-making practices should be based on performer-environment interactions rather than a traditional performer- or task-centered approach (Chow et al., 2009).

A logical consequence of the evolution to more student-centered instructional approaches, such as for example Teaching Games for Understanding (TGfU) and application of motor learning principles for games learning was a comparable shift in research focus. Whereas the initial studies were process/product studies, the focus of the more recent research questions is more about the knowledge construction of the individual learners in relation to their learning environment (Richard & Wallian, 2005).

The purpose of the present study was to investigate if players experience more and/or different learning opportunities while playing 3 on 3 half-court versus 5 on 5 full court basketball game play or in other words if the manipulation of the task constraints (here number of players) results in a differential number and type of learning opportunities.

Methods

Participants

Four junior competition basketball teams or 42 players of 11-12 years old participated in this study. Game play of 30 players (23 boys, 7 girls) (mean age = 11.08 ± 0.55 years) was analysed. Each team was divided in two subgroups (team A and team B) to play against each other during the 5 on 5 (and 3 on 3) games (see table 1). These subgroups remained the same for the two assessment moments. To assure an equal distribution of play level in both subgroups the coach of each team subjectively ranked the players from 10 to 5, where 10 indi-

Table I

Team Compositions Of The Game Play Sessions During The 3 On 3 And The 5 On 5 Assessment Moments

		Assessment moment 1 (5 on 5)		Assessment moment 2 (3 on 3)	
Team	**Session**	**Players^{level} team A**	**Players^{level} team B**	**Players^{level} team A**	**Players^{level} team B**
1	1	$(1)^{10}$-$(2)^{8}$-$(3)^{7}$-$(4)^{6}$-*(31)*^{5}	$(5)^{9}$-$(6)^{8}$-$(7)^{8}$-$(8)^{6}$-*(32)*^{5}	1-2-3	5-6-7
	2	$(1)^{10}$-$(2)^{8}$-$(3)^{7}$-$(4)^{6}$-*(31)*^{5}	$(5)^{9}$-$(6)^{8}$-$(7)^{8}$-$(8)^{6}$-*(32)*^{5}	1-*31*-4	5-*32*-8
	3	$(1)^{10}$-$(2)^{8}$-$(3)^{7}$-$(4)^{6}$-*(31)*^{5}	$(5)^{9}$-$(6)^{8}$-$(7)^{8}$-$(8)^{6}$-*(32)*^{5}	2-3-4	6-7-8
	4	$(1)^{10}$-$(2)^{8}$-$(3)^{7}$-$(4)^{6}$-*(31)*^{5}	$(5)^{9}$-$(6)^{8}$-$(7)^{8}$-$(8)^{6}$-*(32)*^{5}	1-2-*31*	5-6-*32*
2	1	$(9)^{10}$-$(10)^{8}$-$(11)^{6}$-$(12)^{8}$-*(33)*^{7}	$(13)^{9}$-$(14)^{7}$-$(15)^{6}$-$(16)^{8}$-*(35)*^{7}	9-10-11	13-14-15
	2	$(9)^{10}$-$(10)^{8}$-$(11)^{6}$-$(12)^{8}$-*(34)*^{7}	$(13)^{9}$-$(14)^{7}$-$(15)^{6}$-$(16)^{8}$-*(35)*^{7}	*34*-12-*33*	13-16-*35*
	3	$(9)^{10}$-$(10)^{8}$-$(11)^{6}$-$(12)^{8}$-*(33)*^{7}	$(13)^{9}$-$(14)^{7}$-$(15)^{6}$-$(16)^{8}$-*(35)*^{7}	10-11-12	14-15-16
	4	$(9)^{10}$-$(10)^{8}$-$(11)^{6}$-$(12)^{8}$-*(34)*^{7}	$(13)^{9}$-$(14)^{7}$-$(15)^{6}$-$(16)^{8}$-*(35)*^{7}	9-10-*33*	13-14-*35*
3	1	$(17)^{10}$-$(18)^{9}$-$(19)^{8}$-*(36)*^{9}-*(37)*^{6}	$(20)^{10}$-$(21)^{8}$-$(22)^{7}$-*(38)*^{8}-*(39)*^{5}	17-18-*40*	20-21-*38*
	2	$(17)^{10}$-$(18)^{9}$-$(19)^{8}$-*(36)*^{9}-*(37)*^{6}	$(20)^{10}$-$(21)^{8}$-$(22)^{7}$-*(38)*^{8} *(40)*^{4}	17-19-*37*	20-22-*39*
	3	$(17)^{10}$-$(18)^{9}$-$(19)^{8}$-*(36)*^{9}-*(37)*^{6}	$(20)^{10}$-$(21)^{8}$-$(22)^{7}$-*(38)*^{8}-*(39)*^{5}	18-19-*40*	21-22-*38*
	4	$(17)^{10}$-$(18)^{9}$-$(19)^{8}$-*(36)*^{9}-*(37)*^{6}	$(20)^{10}$-$(21)^{8}$-$(22)^{7}$-*(38)*^{8}-*(40)*^{4}	17-18-*37*	20-22-*39*
4	1	$(23)^{8}$-$(24)^{10}$-$(25)^{8}$-$(26)^{9}$-*(41)*^{6}	$(27)^{9}$-$(28)^{10}$-$(29)^{7}$-$(30)^{9}$-*(42)*^{5}	23-24-25	27-28-29
	2	$(23)^{8}$-$(24)^{10}$-$(25)^{8}$-$(26)^{9}$-*(41)*^{6}	$(27)^{9}$-$(28)^{10}$-$(29)^{7}$-$(30)^{9}$-*(42)*^{5}	23-26-*41*	27-30-*42*
	3	$(23)^{8}$-$(24)^{10}$-$(25)^{8}$-$(26)^{9}$-*(41)*^{6}	$(27)^{9}$-$(28)^{10}$-$(29)^{7}$-$(30)^{9}$-*(42)*^{5}	24-25-*41*	28-29-*42*
	4	$(23)^{8}$-$(24)^{10}$-$(25)^{8}$-$(26)^{9}$-*(41)*^{6}	$(27)^{9}$-$(28)^{10}$-$(29)^{7}$-$(30)^{9}$-*(42)*^{5}	23-24-26	27-28-30

Note 1. Of each team only the players with highest ranking (numbers 1 to 30) were included in data-analysis.
Note 2. Italic numbers were not included in the game performance analysis.

cated the player with the highest play level and 5 was used to indicated the player with the lowest play level (see table 1: (player)^{level}). During the 5 on 5 and the 3 on 3 game play the players always marked an opponent of an comparable play level of the other subgroup of their own team. Only one-on-one defence was permitted, between the pairs of attackers and defenders as established previously by the coaches. This last rule, one-on-one defence, was important in that the matching of opposing players enabled differences in technical ability to be more easily controlled. Of each team only the players with highest rankings (numbers 1 to 30) were included in data-analysis (see table I)

Procedure

Data collection. The study consisted of two assessment moments organized on two different testing days during which the players played respectively 5 on 5 and 3 on 3 basketball game play sessions of 5 minutes. Both assessment moments were organized for each team on a day players had no basketball training or were involved in a competition match. At the beginning of each testing day, players started with a warming-up of 10 minutes. Players participated in four 5 on 5 game play session of 5 minutes, with 5 minutes of rest between the game play sessions. This procedure was replicated for the 3 on 3 game play sessions which occurred one week later. Here the players played two or three game play sessions of 5 minutes. Players were told to play 3 on 3 (or 5 on 5) whereby they had to cover the same player (of an equal game performance level) during each 5 minutes game session (see table 1). All game sessions were videotaped to allow post hoc analysis of game performance. To put the entire playing area on the screen 4 digital video cameras (Sony Handycam DCR-HC20E PAL) were used. The 4 cameras were positioned at 3 meter height at both sides of the center line and were pointed in the direction of the basketball goal.

The dimensions of the 5 on 5 basketball court was 14m x 26m, whereas for the 3 on 3 games the court dimensions were 14m x 13m. This implies a relative playing area per individual player of 36.4 m^2 (= 364m^2 /10) in the 5 on 5 game play sessions versus 30.3 m^2 (= 182 m^2 / 6) in the 3 on 3 game play sessions. In both game play situations two basketball goals were used.

Players' heart rates were recorded every 5 seconds during all the game play sessions by means of a heart rate monitor (Polar type RS400). This allowed direct measurement of a physiological response to both game play situations. Heart rates monitored during the rest period were not analysed.

Coding instrument. The coding instrument of Tallir et al. (2007) was used to asses every observable offensive action, both on- and off-the-ball. For every offensive action three game performance components (GPC's) were assessed, namely a decision-making component (DM), a motor skill execution efficiency component (MSEfficiency) and a motor skill execution efficacy component (MSEfficacy). Consequently, each action resulted in a positive or a negative score for each of the three game performance components. The DM component was coded positive/negative when a player took a correct/incorrect decision in a particular game situation. For the MSEfficiency component the different aspects of the executed skill were coded positive / negative when the skill was executed technically correct/incorrect, respectively. The MSEfficacy component was coded positive/negative if the action had a successful / unsuccessful outcome. The entire coding instrument included 95 categories and is presented in appendix 1. Content validity of this instrument was assured in Tallir et al. (2007). The test-retest reliability coefficients of the instrument in this former study were above 0.95 and the Cronbach's inter-observer reliability coefficients were higher than 0.73 for the three components.

An advantage of this coding instrument (see figure) compared to the Game Performance Assessment Instrument (GPAI; Oslin, Mitchell, & Griffin, 1998) is that it made it possible to determine, not only the total number of learning opportunities, but also the proportion, of both the positive and the negative scores, of the four game performance categories (in case: control, scoring and creating scoring opportunities (CSO: dribble, pass, cutting), setting up an attack) because this coding instrument identified every off- and on the ball-action (Tallir et al. 2007) (see appendix 1).

Data-analysis. The software "Catmovie" was used to analyse the offensive (on and off-the-ball) game performance. Catmovie (http://www-campus.uni-r.de/edu1/catmovie/) is a software program that allowed coding all the categories of the GPC (DM, MSEfficiency and MSEfficacy) for every game play action. This software program made it possible to assess all the necessary components and their categories on screen while watching a continuously repeated interval of 5 seconds of the game session before moving on to the next interval. Data-analysis was done in this manner for one player at a time during the entire game play session of 5 minutes. Since the number of 3 on 3 game play sessions (2 or 3 sessions for every player) was not identical to the number of 5 on 5 game play sessions (4 sessions for every player) the average numbers of the three GPC (DM, MSEfficiency and MSEfficacy) per game play session were calculated. Further, as a reflection of game performance, the average proportion of positive scores for the three GPC and the four game performance categories per game play session will be reported in percentages to indicate the distribution of positive and negative scores. Only the positive percentages are reported since the negative percentages are the remaining percentages to 100%.

Statistical analysis. Data were analysed using the Statistical Package for the Social Sciences, version 19.0 (IBM Corporation, New York, USA). Level of significance for all statistical analyses was set at a .05 alpha level and the size of effect was provided by partial Eta squared (η_p^2). Post-hoc LSD test were used to further analyse the main effects.

A repeated measures ANOVA, with one independent (condition: 3-3 vs. 5-5) was used to compare, firstly the differences in the average numbers per session of the three GPC (DM, MSEfficiency, MSEfficacy), secondly the differences in the average positive proportional values of the GPC (DM, MSEfficiency, MSEfficacy) per session.

In a next step the three GPC were analyses in more detail. For the three GPC (DM, MSEfficiency, MSEfficacy) a RMANOVA with repeated measures of the average numbers per session of the game performance categories (in case: control, scoring and CSO (dribbling, passing, cutting actions), setting up an attack) was executed, followed by a RMANOVA with repeated measures of the positive proportional values of the game performance categories (in case: control, scoring and CSO (dribbling, passing, cutting actions), setting up an attack).

To compare the physiological response of the players to both game play situations the heart rate results during the 3 on 3 and 5 on 5 game play sessions a RMANOVA was used to compare the average heart rates of the players in both game play situations.

Results

For the three GPC a main effect condition was found $F_{(3,27)}=78,69$, $p <.001$, $\eta_p^2= .90$. Significantly higher averages numbers were found during the 3 on 3 condition compared to the scores during the 5 on 5 condition (see table II). Effect sizes of the average numbers of the three GPC's were.86, .89 and .88 for DM, MSEfficiency and MSEfficay respectively.

Comparison of the average positive proportional values of the average numbers of the three GPC indicated that for every GPC the positive proportional values were not significantly different in both game conditions $F_{(3,27)}= .74$, p = ns, $\eta_p^2= .08$ (see table III).

The former results were analyzed more detailed at the level of the four game performance categories (in case: control, scoring and CSO, setting up an attack). The average numbers per session of the decision making compo-

TABLE II
Average Numbers Per Session Of The Three Game Performance Components (GPC's: DM, MSEfficiency, MSEfficacy) During 5 On 5 And 3 On 3 Game Play Together With The P-Values And Effect Sizes (H_p^2)

	5on5	3on3	F	p	η_p^2
DM	29.88 (9.49)	50.35 (8.18)	175.22	.001	.858
MSEfficiency	92.23 (40.87)	164.87 (38.81)	239.82	.001	.892
MSEfficacy	30.20 (11.33)	52.09 (10.27)	203.53	.001	.875

Note. Standard deviation in brackets.

TABLE III
Average Positive Proportional Values (In Percentages) Of The Three Game Performance Components (GPC's: DM, MSEfficiency, MSEfficacy) During 5 On 5 And 3 On 3 Game Play

	5on5	3on3
DM	80.15 (10.45)	79.78 (12.76)
MSEfficiency	85.83 (5.83)	83.97 (12.71)
MSEfficacy	78.91 (7.03)	76.75 (13.01)

Note. Standard deviation in brackets.

nents of the game performance categories were significantly different $F_{(6,24)}$= 60,06, $p <.001$, η_p^2= .94 between both game conditions. For all game performance categories, except for setting up an attack significantly higher scores were found in the 3 on 3 condition compared to the scores during the 5 on 5 condition (see table IV). For the game performance category setting up an attack scores were significantly higher in the 5 on 5 condition compared to the 3 on 3 condition for the DM and the MSEfficacy component. For the MSEfficiency higher scores were found for setting up an attack in the 5 on 5 condition. Effect sizes for the game performance categories varied between .36 and .86.

TABLE IV

Average Numbers Per Session Of The Three Game Performance Components (GPC's: DM, Msefficiency, Msefficacy) Of The Game Performance Categories (In Case: Control, Scoring And Creating Scoring Opportunities (CSO: Dribbling, Passing, Cutting Actions), Setting Up An Attack) During 5 On 5 And 3 On 3 Game Play Together With The P-Values And Effect Sizes (H_p^2)

		5on5	3on3	F	p	η_p^2
Decision-making component						
Control [cat 09-10]		5.43 (2.58)	9.85 (2.73)	142.15	.001	.83
Scoring [cat 11-12]		1.65 (1.07)	4.30 (1.74)	107.54	.001	.79
Creating scoring	Dribbling [cat 13-16]	4.18 (2.32)	7.19 (2.34)	88.09	.001	.75
opportunities (CSO)	Passing [cat 14-17]	5.23 (2.66)	8.93 (2.55)	66.11	.001	.70
	Cutting [cat 15-18]	2.75 (1.54)	4.21 (1.43)	31.11	.001	.52
Setting up an attack	[cat 19-20-21-22-23-24]	5.29 (1.52)	3.58 (.96)	24.69	.001	.46
Motor skill efficiency						
Control [cat 25-26-27-28-29-30-31]		4.71 (2.22)	7.07 (1.87)	58.78	.001	.67
Scoring [cat 35-36-37-38-39-40-41-42-43-44-45-46]		1.66 (1.07)	4.31 (1.77)	104.39	.001	.78
Creating scoring opportunities (CSO)	Dribbling [cat 47-48-49-50-51-52-53-54-55-56]	3.21 (1.89)	5.55 (2.07)	78.08	.001	.73
	Passing [cat 57-58-59-60-61-62]	3.92 (2.10)	6.34 (1.81)	49.45	.001	.63
	Catching [cat 63-64-65-66-67-68]	5.49 (2.44)	9.92 (2.51)	162.73	.001	.85
	Cutting [cat 69-70-71-72-73-74]	2.47 (1.51)	3.89 (1.57)	25.49	.001	.47
Setting up an attack	[cat 75-76-77-78]	3.02 (.68)	4.34 (1.38)	23.02	.001	.44
Motor skill efficacy						
Control [cat 79-80]	5.24 (2.58)	9.69 (2.69)	174.03	.001	.86	
Scoring [cat 81-82]	1.68 (1.07)	4.24 (1.73)	90.14	.001	.76	
Creating scoring	Dribbling [cat 83-84]	3.76 (2.20)	6.52 (2.54)	78.15	.001	.73
opportunities (CSO)	Passing [cat 91-92-93]	9.88 (4.52)	17.336 (4.38)	125.82	.001	.81
	Cutting [cat 85-86-87-88-89-90]	.95 (.63)	1.45 (.60)	16.24	.001	.36
Setting up an attack	[cat 94-95]	8.72 (2.75)	6.03 (1.38)	23.63	.001	.45

Note. Standard deviation in ( ) brackets. Detailed description of the game performance categories can be found in the appendix and is noted in [ ] brackets.

In a next step the focus is on the positive proportional values of the game performance categories. Comparison of the average positive proportional values of the decision making components of the game performance categories (in case: control, scoring CSO (dribbling, passing, cutting actions), setting up an attack) resulted in a main effect of condition $F_{(6,24)}$= 3.34, p <.05, η_p^2= .46 (see table V). Significantly higher averages positive proportional values of the decision making component during the 3 on 3 condition were only found for the game performance category CSO cutting actions compared to the 5 on 5 condition $F_{(1,29)}$= 12,59, p <.001, η_p^2= .30 (see table V). Identical analyses were executed on the average positive proportional values of the motor skill efficiency and efficacy components of the game performance categories. Results for the motor skill efficiency component $F_{(6,24)}$= .36, p = ns, η_p^2= .08 and for the motor skill efficacy component $F_{(7,23)}$= 2.17, p = ns., η_p^2= .40 showed no significant differences between both conditions when comparing the average positive proportional values of the both components of the game performance categories (see table 5).

TABLE V

Average Positive Proportional Values Of The Three Game Performance Components (GPC's: DM, Msefficiency, Msefficacy) Of The Game Performance Categories (In Case: Control, Scoring And Creating Scoring Opportunities (CSO: Dribbling, Passing, Cutting Actions), Setting Up An Attack) Together With The P-Values And Effect Sizes (H_p^2)

		5on5	3on3	F	p	η_p^2
Decision-making component						
Control		87.37(13.61)	85.88(14.68)	.33	ns	.011
Scoring		76.79(29.93)	86.66(15.15)	2.33	ns	.074
Creating scoring	Dribbling	73.62(25.63)	77.84(19.02)	.96	ns	.032
opportunities (CSO)	Passing	85.70(10.60)	85.32(11.00)	.03	ns	.001
	Cutting	57.01(27.08)	43.08(21.94)	12.59	.001	.303
Setting up an attack		81.78(14.10)	82.84(13.69)	0.14	.ns	.005
Motor skill efficiency						
Control		92.85 (6.22)	90.09 (8.63)	3.96	ns	.120
Scoring		88.19 (2.75)	95.79 (3.79)	2.85	ns	.090
Creating scoring	Dribbling	91.74 (17.70)	90.37 (17.59)	0.09	ns	.003
opportunities (CSO)	Passing	86.92 (7.89)	85.82 (10.58)	.27	ns	.009
	Catching	90.26 (8.68)	91.10 (7.20)	.45	ns	.015
	Cutting	41.15 (25.08)	32.59 (21.44)	6.69	ns	.188
Setting up an attack		69.26 (19.18)	72.24 (18.61)	.92	ns	.031
Motor skill efficacy						
Control		99.44 (2.12)	98.86 (3.31)	1.36	ns	.045
Scoring		48.51 (27.07)	45.95 (21.28)	.14	ns	.005
Creating scoring	Dribbling	90.09 (20.12)	92.46(18.24)	.21	ns	.007
opportunities (CSO)	Passing	91.57 (5.21)	92.66 (4.43)	.72	ns	.024
	Cutting	29.34 (27.04)	30.31 (24.01)	.06	ns	.002
Setting up an attack		72.30 (19.81)	73.39 (18.79)	.12	ns	.004

Note. Standard deviation in brackets.

Comparison of the average heart rates in both game play conditions $F_{(1,28)}= 7{,}0$, $p <.05$, $\eta_p^2= .20$ resulted in significantly higher heart rates in the 5 on 5 condition (M = 185.07 ± 10,76) compared to the 3 on 3 condition (M = 180.80 ± 12,10).

Discussion

A crucial prerequisite for (motor) learning to occur is exercising, and more specifically the frequent repetition of a skill (Newell, 1996). For games teaching, this means it is crucial to select appropriate learning activities (Silverman, 2003*)* that reflect players' developmental readiness and that allow certain aspects of the game to come into play more often so that players get more in-game repetitions on key tactics and motor skills (Metzler, 2000). So, in games teaching the learning activities should contain constraints that are representative of those that players will face during game play (Renshaw et al., 2010) for an integrated development of both components of game performance. In the absence of a theoretical framework a similar statement was already made by Turner and Martinek (1992) two decades earlier, namely that through game play more adaptable schemata for motor skills may be developed.

The general purpose of this study was therefore to compare the amount of learning opportunities in the 3 on 3 modified game compared to the 5 on 5 full basketball game. For the assessment of the number of learning activities and the related game performance the game performance coding instrument of Tallir et al. (2007) was used. This instrument distinguishes three GPC's (the decision-making component, the motor skill execution efficiency component and the motor execution efficacy component) of every observed offensive action, on and off-the-ball and was consequently preferable to the Game Performance Assessment Instrument (GPAI) (Oslin et al., 1998) where all "decisions made" are assessed as one game component, which makes it impossible to identify in more detail whether a decision is related to dribbling, passing or shooting.

The significantly higher scores on the three GPC in the 3 on 3 game play condition indicated that in this game play situation players experienced more learning opportunities compared to the 5 on 5 full game play condition. This confirms Metzlers' (2000) statement that small-sided or modified games (in this study the 3 on 3 game play), contain more in-game repetitions of key tactics and motor skills. Capel (2000) noted that small-sided games provide more learning opportunities compared to the full game. When the focus is on the analysis of the different game performance categories (control, score, CSO and setting up an attack) the larger amount of learning opportunities in the 3 on 3 game play situation is only found for the game performance categories control, score, CSO. This may originate from the smaller amount of players which indirectly offered the players more space and time to make decisions and to execute these decisions. For the game performance category setting up an attack the numbers in the DM component and the MSEfficacy component were higher in the 5 on 5 game play situation, while the MSEfficacy component showed higher scores in the 3 on 3 game play situation. In the 5 on 5 condition players may experience the need for setting up more than in the 3 on 3 game play situation because of the crowed situation with ten players on the playing field. The actions related to setting up an attack are however not executed correctly, whereas they show nevertheless have a successful outcome. This finding shows similarities to the variability principle of the constraints-led approach (Davids et al., 2008). However, it should be acknowledged that the assessment of the MSEfficiency component was not detailed enough in this study to effectively draw this conclusion.

If the increase in learning opportunities found in this study results in an improvement of game performance remains an unanswered question. Comparison of the game performance of the players in both game play situations showed that the positive proportional values of the three GPC's are not significantly different in both game play situations, except for the cutting actions. In the 5 on 5 game play the proportion of positive cutting actions in the decision-making component was significantly higher as compared to the 3 on 3 game play. This may originate from the fact that during 5 on 5 game play players execute more actions off the ball since they have less opportunities to execute on the ball actions because of the larger number of players.

The results of the present study underline the importance of future research to investigate to what extent learning results are easier or faster attained when applying the non-linear pedagogy principles (Davids et al., 2008). It is necessary to evaluate the impact of the manipulation of a task constraint, e. g. the rules of the game, the equipment used, size of the playing area, and number of players involved during a learning experiment on games teaching. This should add empirical support to the current lack of strong evidence (Strean and Bengoechea, 2002) in favour of the more student-centered instructional approaches such as Teaching Games for Understanding (TGfU). It was stated a decade ago by Rink (2001) that selection of the learning task may be one of the most important decisions made by physical education teachers and this still holds true as illustrated by Chow et al. (2009) who mentioned that it is a challenge for future research to extend understanding of nonlinear pedagogy principles in games teaching research.

Another unanswered question in this domain is the search for the optimal game play situation to assess game performance or what game situation with its specific constraint reflects the developmental status of the players whose game performance is to be assessed. This nonlinear pedagogy research topic may even be extrapolated to investigation of the statement made by Silverman (2003) that players will learn more if they get developmental appropriate practice during the game play learning activities holds.

Overall, the findings of this study showed that 10-11 year old players experienced more learning opportunities during 3 on 3 game play as compared to 5 on 5 game play. Since creating learning situations with a lot of learning opportunities is not an isolated objective, in physical education lessons as well as in competitive training sessions, the physical load was measured in both game play situations. Results showed that players had significantly lower average heart rates while playing 3 on 3 game play as compared to the 5 on 5 full game. Heart rates between 170 and 190 BPM are an indicator of high physical exertion, whereas heart rates above 190 BPM occur during maximal physical exertions. Since the heart rate results of the players in this study are both covered by the zone of high physical exertion the difference found between both game play conditions should be nuanced. Apparently, the smaller dimensions of the basketball court in the 3 on 3 small-sided games, resulting in the lack of long runs during counterattacks, did not result in clear differential physical requirements compared to the full game. The conclusion with regard to the physical activity and fitness aims in physical education lessons as well as in basketball training is that full games as well as small-sided games can be used to obtain these goals, but that small-sided games (in case 3 on 3) have the additional advantage of more potential for learning (and improving) decision-making and motor skill execution.

A limitation of the present study is the fact that the dynamic environmental interactions are not taken into account (Chow et al 2007) in the analysis of game performance. In a recent study of Vilar, Araujo, Davids and Button (2012) the ecological dynamics framework is proposed as a framework to substantiate insights in successful and unsuccessful performance in game play. The assessment of the MSEfficacy component of game performance in this study is far more rudimentary. In fact, it is limited to the assessment of the observed outcomes of the decisions as they are executed by players during game play (Turner & Martinek, 1999).

A final suggestion for future research is related to the fact that repetition, an important component of exercising, is related to the number of learning opportunities and is, indeed, a very important prerequisite for learning to occur. However, one should avoid that players are guided continuously during game play, culminating in the development of teacher or coach dependent performers (Turner & Martinek, 1992). Therefore it is important that learning activities, such as small-sided games, provide players with a maximum of in-game repetitions of motor skills without losing the focus on practising decision-making skills and thus enticing players to continuously reflect on their game performance. Therefore the instructions and feedback the learners receive also need to be carefully chosen. According to Metzler (2000) players' motivation and thus their learning results depend on the presence of challenging learning activities. An interesting aspect for future research may be to investigate the motivational aspects of these small-sided games compared to the full game.

Appendix

The game performance coding instrument (Tallir et al. 2007)

Date Condition
Participants' number

Game performance	Decision-making component	Motor skill execution component	Effectiveness component
Control	Pivoting in the direction of the basket. (cat09)	Holding the ball with two hands. (cat25) Knees, hip and elbow bent. (cat26) Feet parallel and aimed at the basket. (cat27) Pivoting without travelling foul. (cat28) Pivoting according to the position of the defender. (cat29)	Player stays in possession of the ball. (cat79)
	Not pivoting or not pivoting in the direction of the basket. (cat10)	Holding the ball with one hand or holding the ball with two hands but close to the floor. (cat30) Knees, hip and elbow not bent. (cat31) Feet not parallel and not aimed at the basket. (cat32) Pivoting with travelling foul. (cat33) Pivoting without taken the position of the defender into account. (cat34)	Player looses the ball. (cat80)
Scoring	Standing close to the basket and trying to score when there is no defender nearby. (cat11) Standing close to the basket and not trying to score when there is no defender nearby. Standing far away from the basket and trying to score while there was free space to dribble closer to the basket. Standing under the basket and trying to score. Trying to score while a team-mate was in a favourable position. Trying to score while there is close defence. (cat12)	Feet parallel and aimed at the basket. (cat35) Holding the ball in shooting pocket. (cat36) Overhand shooting. (cat37) Bow in trajectory of the ball. (cat38) Clear flexion-extension movement. (cat39) Ball hits square on the basket or the ring. (cat40)	Ball ends in the basket. (cat81)
		Feet not parallel and not aimed at the basket. (cat41) No shooting pocket. (cat42) Not shooting overhand. (cat43) No bow trajectory of the ball. (cat44) Clear flexion-extension movement is missing. (cat45) Ball misses square on the basket or the ring. (cat46)	Ball misses the basket. (cat82)

(Continued)

Date Condition Participants' number				
Game performance		**Decision-making component**	**Motor skill execution component**	**Effectiveness component**
Creating Shooting Opportunities	*Dribbling*	Dribbling to take the free space to the basket. Dribbling to create space. (cat13)	No travelling foul at the start of the dribble. (cat47) No travelling foul during the dribble. (cat48) No travelling foul at the end of the dribble. (cat49) Dribble with view on the game. (cat50)	Dribble ends in a scoring opportunity. Players stays in possession of the ball. (cat83)
		Dribbling on the spot. Not dribbling while there was free space to the basket. Dribbling while a team-mate stands free in a favourable scoring position. (cat16)	Travelling foul at the start of the dribble. (cat51) Travelling foul during the dribble. (cat52) Travelling foul at the end of the dribble. (cat53) Dribble with the back aimed at the game. (cat54) Not dribbling while moving with the ball. (cat55) Useless dribble (e.g. when catching a ball). (cat56)	Player looses the ball. (cat84)
	Passing	Pass to a team-mate who stands free and/or in a more favourable position. (cat14) Pass while there was free space to dribble to the basket.	In the cutting direction. (cat57) Not too high, not to far. (cat58) Passing with two hands (chest or bounce pass). (cat59)	Ends in ball possession. (cat91)
		Pass to a team-mate who does not stand free. Pass to a team-mate while there was a scoring opportunity. (cat17)	Not in the cutting direction. (cat60) Too high, to far, not far enough. (cat61) Not passing with two hands (no chest or bounce pass). (cat62)	Ball possession (after control with dribble). (cat92) Ball is lost. (cat93)
	Catching		In the running direction. (cat63) Not too high, not too far. (cat64) With two hands. (cat65)	Ends in ball possession. (cat91)
			Not in the running direction. (cat66) Too high, too far.(cat67) Not with two hands. (cat68)	Ball possession (after control with dribble). (cat92) Ball is lost. (cat93)

(Continued)

Date Condition
Participants' number

Game performance		Decision-making component	Motor skill execution component	Effectiveness component
Creating Shooting Opportunities	*Cutting*	Cutting to the basket after giving a pass. Not cutting to the basket while the player with the ball undertakes an action to the basket. (cat15)	Cutting immediately after giving a pass. Not cutting when there is an action to the basket. (cat69) Asking the ball while cutting. (cat70) Eye contact while cutting. (cat71)	Leads to a good passing opportunity. (cat85) Leads to ball possession. (cat86) Leads to a scoring opportunity. (cat87)
		Cutting to the basket while the player with the ball undertakes an action to the basket. Not cutting after giving a pass. Running behind the player with the ball. Cutting and returning immediately. (cat18)	Not cutting immediately. Cutting while there is an action to the basket. (cat72) Not asking the ball while cutting. (cat73) No eye contact while cutting. (cat74)	Does not lead to a good passing opportunity. (cat88) Does not lead to ball possession. (cat89) Does not lead to a scoring opportunity. (cat90)
Setting up an attack		Moving to lose the defence. Player is free in the around the spots. (cat19) Not moving when he can receive the ball. (cat20) Player can receive the ball left and right from the player with the ball. (cat21)	Change of speed and direction. (cat75) Free, remain standing. (cat76)	
		Remain standing with defence in the passing lane. (cat22) Free but too far away from the player with the ball. (cat23) Free, but not remain standing. Two players on one side of the ball. (cat24)	No change of speed and direction. Remain standing in a useless position. (cat77) Free, but not remain standing. (cat78)	Player can receive the ball. (cat94) Player cannot receive the ball. (cat95)

REFERENCES

Araújo, D., Davids, K., Bennett, S, Button, C, & Chapman, G. (2004). Emergence of sport skills under constraint. In A. M. Williams, & N.J. Hodges (Eds.), *Skill acquisition in sport: Research, theory and practice* (pp. 409-433). London: Routlegde, Taylor & Francis.

Capel, S. (2000) 'Approaches to teaching games' in S. Capel and S. Piotrowski (eds). *Issues in physical education* (pp. 81-98) London and New York: Routledge Falmer, Taylor & Francis Group.

Chow, J. Y., Davids, K., Button, C., Shuttleworth, R., Renshaw, I., & Araújo, D. (2006). Nonlinear pedagogy: A constraints-led framework to understand emergence of game play and skills. *Nonlinear Dynamics, Psychology and Life Sciences, 10*(1), 74-104.

Chow, J., Davids, K., Button, C., Shuttleworth, R., Renshaw, I., & Araújo, D. (2007). The role of nonlinear pedagogy in physical education. *Review of Educational Research, 77*(3), 251-278.

Chow, J.Y., Davids, K., Button, C., Renshaw, I., Shuttleworth, R., Uehara, L. A. (2009). Nonlinear pedagogy: implications for teaching games for understanding (TGfU). In T. F. Hopper, J. Butler, & B. Storey (Eds.), *TGfU: Simply good pedagogy: understanding a complex challenge*. Ottawa: Physical Health Education Association (Canada).

Davids, K., Button, C. & Bennet, S. (2008). *Dynamics of skill acquisition: a constraints-led approach*. Champaign, IL: Human Kinetics.

Gréhaigne, J. F., Bouthier, D., & David, B. (1997). Dynamic-system analysis of opponent relationships in collective actions in soccer. *Journal of Sport Sciences, 15*(2), 137-149.

Griffin, L. L., Butler, J., Lombardo, B., & Nastasi, R. (2003). An introduction to teaching games for understanding. In J. Butler, L. Griffin, B. Lombardo & R. Nastasi (Eds.), *Teaching games for understanding in physical education and sport*. VA: NASPE Publications.

Griffin, L. L., & Butler, J.(2005*). Teaching Games for Understanding – Theory, research and practice*. Champaign, IL: Human Kinetics.

McGarry, T., Anderson, D. Wallace, S., Hughes, M. & Franks, I. (2002). Sport competition as a dynamical self-organizing system. *Journal of Sport Sciences, 20*, 771-881.

Metzler, M. W. (2000). *Instructional models for physical education*. Boston: Allyn and Bacon.

Mitchell, S.A., Oslin, J.L., & Griffin, L.L. (1995). The effects of two instructional approaches on game performance. Pedagogy in practice. *Teaching and coaching in physical education and sport, 1*, 36-48.

Newell, K.M. (1986). Constraints on the development of coordination. In M.G. Wade, & H.T.A. Whiting (Eds.), *Motor development in children. Aspects of coordination and control* (pp. 341-360). Dordrecht, Netherlands: Martinus Nijhoff.

Newell, K.M. (1996). Change in movement and skill: Learning, retention and transfer. In M.L. Latash, & M.T. Turvey (Eds.), *Dexterity and its development* (pp. 393-430). Mahwah, NJ: Erlbaum.

Oslin, J. L., Mitchell, S. A., & Griffin, L. L. (1998). The game performance assessment instrument (GPAI): Development and preliminary validation*. Journal of teaching in physical education, 17*, 231-243.

Passos, P., Araújo, D., Davids, K., & Shuttleworth, R. (2008). Manipulating constraints to train decision making in rugby union*. International Journal of Sport Science & Coaching, 3*(1), 125-140.

Renshaw, I., Chow, J. W., Davids, K. & Hammond, J. (2010). A constraints-led perspective to understanding skill acquisition and game play: a basis for integration of motor learning theory and physical education praxis? *Physical Education and Sport Pedagogy, 15*(2), 117-137.

Richard, J., & Wallian, N. (2005). Emphasizing student engagement in the construction of game performance. In L. L. Griffin, & J. Butler (Eds.), *Teaching Games for Understanding – Theory, research and practice*. Champaign, IL: Human Kinetics.
Rink, J. (2001). Investigating the assumptions of pedagogy. *Journal of Teaching in Physical Education, 20*, 112-128.
Silverman, S. (2003). The pedagogy of motor skill learning: Teachers and students. In A. Laker (Ed.), *The future of physical education* (pp. 102-120). London: Routledge, Taylor & Francis Group.
Strean, W. B., & García Bengoechea, E. (2003). Beyond technical vs. tactical: Extending the games teaching debate. In J. Butler, L. Griffin, B. Lombardo, & R. Nastasi (Eds.), *Teaching games for understanding in physical education and sport: An international perspective.*.VA: NASPE publications.
Tallir, I. B., Lenoir, M., Valcke, M., Musch, E. (2007). Do alternative instructional approaches result in different game performance learning outcomes ? Authentic assessment in varying game conditions. *International Journal of Sport Psychology, 38*, 263-282.
Thomas, K. T., French, K. E., & Humphries, C. A. (1986). Knowledge development and sport skill performance: Directions for motor behaviour research. *Journal of Sport Psychology, 8*, 259-272.
Turner, A.P., & Martinek, T.J. (1992). A comparative analysis of two models for teaching games (technique approach and game-centered (tactical focus) approach). *International Journal of Physical Education, 29*(4), 15-31.
Turner, A.P., & Martinek, T.J. (1999). An investigation into teaching games for understanding: Effects on skill, knowledge and game play. *Research Quarterly for Exercise and Sport, 70*(3), 286-296.
Vilar, L., Araujo, D., Davids, K.,& Button, C. (2012). The role of ecological dynamics in analyzing performance in team sports. *Sports Medicine, 42*(1), 1-10.

Manuscript submitted May 2012. Accepted for publication September 2012.