

IMPLICATIONS OF SPORT BIOMECHANICS ON TEAM BALL GAMES

PEKKA LUHTANEN

RESEARCH INSTITUTE FOR OLYMPIC SPORTS, JYVÄSKYLÄ, FINLAND

INTRODUCTION

In ball games, players can move with or without ball using varying patterns of motion, techniques to master the ball with feet or hands or puck with stick and tactical decisions to master the game. All actions vary in duration, space, speed and direction. Each individual action by a player can be considered as a random test for individual **skills** and tactical understanding in game. The **skill** output in the game conditions can be measured using video observation and analysis methods and in testing conditions using traditional **skill** tests. Tactical understanding can be evaluated with sequence analysis of the pattern of play and **questionnaires** or psychomotor tests.

Analysis of video recordings have been used to study game actions in soccer both qualitatively and quantitatively. Individual techniques with ball in soccer and basketball matches and with puck in ice hockey have been evaluated at junior level with video analysis (Luhtanen et al. 1986).

The purpose of this presentation was to conclude the relationships of individual and team **skills** in match and test conditions, understanding of the game, physical and psychomotor abilities in young soccer, basketball and ice hockey players as a result of several Finnish studies.

METHODS

Both transversal (soccer, basketball, ice hockey) and longitudinal (ice hockey) studies were **carried** out. The number of subjects in the age group from seven to nineteen years were in ice hockey, soccer, and basketball 342, 138 and **85**, respectively. The development of team **skills** in match conditions were explained by game understanding including rules and player behaviour in selected situations of the games, **decision-making** speed, tested playing **skills**, physical performance tests, group dynamics, quantity and quality of training (Figure 1).

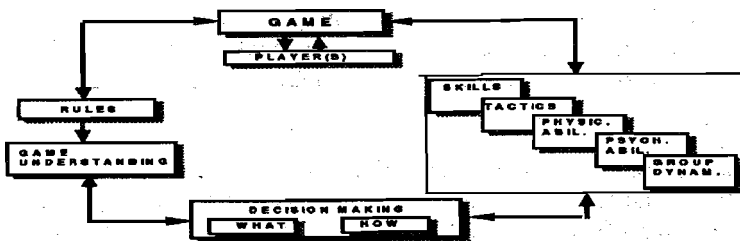


Figure 1. The framework to evaluate the development of the team and individual **skills** in team ball games

The development of team skills were evaluated in all games using the total number of manoeuvres with ball or puck, passes, receptions, interceptions, dribbles, scoring shots and percentage of successful actions related to the mentioned manoeuvres. The basic match analysis in all games were achieved using a video recording and playback system and observation sheets with the operationally defined qualitative and quantitative variables. Selected conventional field tests were cumed out in soccer (Luhtanen 1988), basketball (Luhtanen 1989) and ice hockey (Luhtanen, 1990,

Luhtanen & Salminen 1991). The relationships between skills in test and match was evaluated with multivariate analysis. Also the relative successful actions in match conditions were described with forced and stepwise regression analysis using selected background tests as independent variables. For the further analyses new variables were calculated. The independent test variables were constructed as follows:

1. The individual skill index (SI) was the average value of the tests in the different skill tests with ball or puck,
2. The speed index was the average maximal running or skating speed (MRS) in the distance of 30 meters,
3. The index of explosive leg strength was indirectly the vertical jumping strength (VJS) as jumping height in maximal vertical jump,
4. The index of the reaction speed was the inverse of choice reaction time (CRS) to the light signal with fingers,
5. The total index of game understanding (TIU) of the game was measured using multichoice questionnaires concerning the purposeful action of one player, a player group and knowledge of the rules. TIU was calculated as the sum of these variables.
6. The index of skating endurance (SKE) in ice hockey was the average speed in the shuttle skating test of 218 meters.

The linear forced regression analysis was applied to the successful action in match conditions and tested background variables as follows:

1. The dependent variables were separately the percentage the successful manoeuvres (PSM) in receiving the ball or puck, passing the ball or puck, dribbling with ball or skating with puck and passing combination, interceptions, face-offs in ice hockey, shooting and total average of all successful manoeuvres
2. The independent variables were the individual skill index, the index of running or skating speed, explosive leg strength, reaction speed, skating endurance and total index of understanding of the game.

The formula (1) for the forced linear regression equation was as follows:

$$PSM_i = a * SI + b * MRS + c * TIU + d * VJS + e * CRS + f * SKE + C, \quad (1)$$

where, a-f = linear regression coefficients and C = constant.

In the longitudinal study of ice hockey, a modification of the formula (1) and independent variables were applied (Luhtanen & Salminen 1991). The independent variables were individual speed-skill index, skating speed index, index of speed-strength, index of the reaction speed and index of skating speed-endurance.

The linear regression analysis was performed with computer and SPSS-X software. For the testing of statistical significance F-ratio was applied.

RESULTS

The total amount of actions in the soccer match analysis with the ball was 4800 (Luhtanen 1988b). Relatively the players succeeded in their attempts as follows: passing 50 %, receiving 69 %, dribbling 38 %, shooting technically 66 % and goal scoring 8 %, interceptions 59 % and dead balls 58 %. The linear regression analysis was applied to explain the percentage of the successful receiving, passing, dribbling-passing combination, interceptions, dead balls, shooting and average of all manoeuvres with the independent test variables. The skills of all manoeuvres in match conditions was explained with the independent test variables as follows (Luhtanen 1990b):

$$SNE = 3.31 * TSI + 3.89 * MRS - .07 * TIU - .30 * VJS - .07 * CRT + 64.05 \quad (2)$$

$$(R = .50, F = 7.05, p < .001)$$

The total amount of actions in the basketball match analysis with the ball was 4163 (Luhtanen 1989). Relatively the players succeeded in their attempts as follows: passing 92 %, receiving 95 %, dribbling 61 %, rebounds 68 % and for scoring 31 %. The linear regression analysis was applied to explain the percentage of the successful receiving,

passing, dribbling-passing combination, interceptions, rebounds, shooting and average of all manoeuvres with the independent test variables. The **skills** of all manoeuvres in match conditions was explained with the independent test variables as follows (Luhtanen 1991):

$$SMC = .31*TSI - .18*MRS + .14*TIU - .03*VJS - .05*CRT + 71.93 \quad (3)$$

(R = .430, F = 1.75, p < .15)

The total amount of actions in the match analysis with the puck was 7112 (Luhtanen 1990a). Relatively the players succeeded in their attempts as follows: passing 57 %, receiving 79 %, skating with puck 57 %, **shooting** technically 68 % and for scoring 10 %. The linear regression analysis was applied to explain the percentage of the successful receiving, passing, skating with puck and passing combination, interceptions, face-offs, **shooting** and average of all manoeuvres with the independent test variables. The **skills** of all manoeuvres in match conditions was explained with the independent test variables as follows (Luhtanen 1990c):

$$SMC = 2.58*SI - 1.17*MRS + .26*TIU + .20*VJS - .02*CRT + 2.01*SKE + 51.12 \quad (4)$$

(R = .460, F = 8.00, p < .001)

Small differences were found in the average values between teams in the same age category. Large differences were found in the individual **skills**, perceptual abilities, game understanding and physical abilities. As a dependent variable, the successful actions in match conditions were explained with independent variables (**skill**, speed, strength, endurance, and their combinations).

Table 1 explains a concluding relationship of selected dependent and independent variables for the best ice hockey team (a Slovakian) participating five years in the longitudinal study.

Table 1. Average dependence of the different tests on successful actions in a Slovakian team. (CR = choice reaction speed)

Dependent variable	Independent variable					CR-speed
	Speed-skill	Speed	Speed-strength	Speed-endurance		
Receiving		+	+	+	+	0
Passing	++	0	-		+	
Puck-carrying	+	+	0	+	0	
Shots	+	0	0		0	
In total	++	+	+	+	0	

++ = strong positive relationship + = light positive relationship
 0 = no relationship
 - = light negative relationship -- = strong negative relationship

In all games **skill** and speed explained, dominantly, the success in **match** conditions. Also, the **organisational** (team selection and training) and team sociological factors played important role with respect to the success of the teams (Luhtanen & Salminen 1991. Salminen & Luhtanen 1993).

DISCUSSION

The meaning of the individual team game **skills**, psychomotor and physical abilities and tactical understanding of the game have been speculated often in the practical ball

game coaching. In this presentation, it has been shown clearly that at junior level the age, physical abilities, psychomotor skills, and game like skills are influencing on the success in the match. As evidence for this was found that the losers were behind the winners in the tested game like **skills**, physical strength and speed and psychomotor choice reaction speed. In addition, the losers had less time to control the ball and puck in different game manoeuvres. However, the losers were often better than the winners in understanding the game tactically. It can be easily understood that only to know how the situation should be solved is not enough in game if the weapons for executing the actions in practise are insufficient.

In this presentation the relationships between the tested skills, understanding the game and physical abilities like running speed and jumping height were higher than the corresponding correlations between the successful actions in passing, receiving, dribbling, and shooting. This could mean that the training programs for the total training have not **been** well balanced for the total development of the players. It could be suggested that when the coaches are planing their future programs the better balance between the **skill**, tactical and physical training should be kept in mind.

In conclusion, it could be stated that the players with higher running and skating, decision **making** velocity, better ball and puck control. **skills** and understanding have more time in the game situation to read the game and execute the purposeful decisions for the existing situations than the players with the lower corresponding velocities, **skills**, and abilities.

REFERENCES

- Luhtanen, P.(1988a). Reliability of video observation of individual techniques used in soccer match. In: Science and football, eds. Reilly, T., Lees, A., Davids, K., Murphy, W.J., pp. 356-360, E. & F.N. Spon, London.
- Luhtanen, P.(1988b). Relationships of individual **skills**, tactical understanding and team skills in Finnish junior soccer players. In: New Horizons of Human Movements, Proceedings of the 1988 Seoul Olympic Scientific Congress, Volume II, pp. 1217-1221, Seoul.
- Luhtanen, P.(1989). Relationships of individual **skills**, tactical understanding and team **skills** in Finnish junior basketball players. Proceedings of VII International Symposium of ISBS, ed. W. Morrison, pp. 73-78, Footscray Institute of **Technolgy**, Footscray, Australia.
- Luhtanen, P.(1990a). Relationships of individual skills, tactical understanding and team **skills** in Finnish junior ice hockey players., In: Physical Education and Life-Long Physical Activity, The Proceedings of AIESEP World Convention, Eds. Telama, R. et al., pp. 215-220, **Gummerus Kirjapaino Oy, Jyväskylä**.
- Luhtanen, P.(1990b). Relationships between successful **skill** manoeuvres in match conditions and selected test variables in soccer players. In: Congress proceedings of the International Conference Sports Medicine Applied to Football, Ed. Santilli, G., p. 437, **CONI**, Rome, Italy.
- Luhtanen, P.(1990c). Relationships of successful manoeuvres in selected match and test conditions in junior ice hockey players. In: Proceedings of the **VIIIth** International Symposium of the Society of Biomechanics in Sports, eds: **Nozek, M**, Sojka, D, Morrison W.E. & **Susanka**, P. pp. 95-97, **Conex** Company, Prague.
- Luhtanen, P.(1991). Relationships of successful manoeuvres in match, individual **skills**, running and reaction speed, leg strength and game understanding in junior **basketball** players. In: C. Tant, P.E. Patterson & S.L. York, Biomechanics in Sports IX, pp 157-160. Iowa State University Press, **Ames**, Iowa.
- Luhtanen, P., K. Nieminen, E. Helimäki, E. **Westerlund** & P. **Mäkinen**.(1986). Qualitative and quantitative analysis of team games by computer. University of **Jyväskylä**, Department of Physical Education, Finland, **Serie A** 19: 1-54.
- Luhtanen, P. & Salminen, S.(1991). The effects of a five year training on playing skills of Finnish, Swedish and **Czechoslovakian** junior ice hockey teams. Research Reports from the Research Institute for Olympic Sports, **Jyväskylä** 2:1-31.
- Salminen, S. & Luhtanen, P.(1993). Testing the theory of role differentiation with a five year follow-up study of junior ice **hockey** players. In: Motivation, Emotion, stress, Vol. 1. eds. Nitsch, J.R. & Seiler, R., pp. 56-59, **Academia Verlag, Sankt Augustin**, Germany.