

Analysis of expert's opinion of optimal beginning age for learning technical skills in water polo

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Purpose: Optimizing the training process of young water polo players according to children's developmental characteristics and didactic principles is of pivotal importance; however, there is a lack of research in the area. Therefore, we sought to determine and explain the appropriate age for beginning of learning technical elements in water polo according to water polo experts' coaches' opinion.

Methods: In accordance with the objective, 27 expert water polo coaches completed the newly constructed questionnaire designed for this study. Reliability of the measuring instrument was examined using test-retest method on the entire sample and it was found to be satisfactory (r ranged from 0.85 to 1.00 with $P < .05$ for all variables). Exploratory strategy of factor analysis together with *Guttman-Kaiser* criterion and *varimax* raw rotation were used to reduce dimensionality of the data.

Results: The results indicate the existence of four real life existing factors: (1) *Basic ball manipulation, basic shots and explosive movements*; (2) *Basic water polo movements and shots from the central forward position*; (3) *Complex movements, ball manipulation and shots*; (4) *Activity for the preparation and execution of the most demanding backhand shots* 31%, 17%, 15%, 9% of the variability of manifest space, respectively.

Conclusions: These results yield hitherto unseen insight into experts' opinion on optimal age for beginning to learn complex water polo movements and can provide important guidance for trainers in structuring curriculum of the training process for all young water polo players.

Keywords: water polo experts, technical elements, new teaching methodology, didactic principles, early specialization

Introduction

Every complex human movement takes place in a certain order; this also applies to training and development. In the training process, the ranges, intensities and sequences of teaching training contents are determined. The training curriculum is mainly compiled according to certain criteria and epistemological and didactic knowledge to determine technical and tactical skills. Unfortunately, to our knowledge, there are no known studies that have dealt with expert opinions with the aim of determining the optimal age of acquiring technical knowledge, neither in water polo nor in any other sports activity.

The didactic principles are general norms through which teaching-learning-evaluating is put into practice, so that the functioning of the objectives/competences become efficient at the level of the educational dimension¹. When arranging training contents, some of the basic didactic rules on gradualness are usually followed, i.e., from easier to harder, from simpler to complex, and from the known to the unknown². A top water polo player must be strong, fast, and durable, and technically and tactically well developed. In order for a water polo player to reach the highest quality, it takes years of systematic and methodologically correct training. In the search for optimization of the training process according to children's developmental characteristics, a new teaching methodology has been determined and explained³. Indeed, by determining the optimal age for learning technical skills, we can

avoid early specialization. A focus on specialized training during the early stages of development has been linked with several negative consequences⁴. Moreover, for most sports, there is no evidence that intense training and specialization before puberty are necessary to achieve elite status^{5,6}.

Water polo technique is a set of biomechanically accurate and efficient game elements, which are necessary for solving specific tactical tasks. Technical elements must be based on the rules of the water polo game and be applied according to the situations within the game⁷. The performance skill in terms of technical elements is necessary for the attainment of elite athletic achievements because only the properly acquired and perfected technical elements enable the use of the most efficient tactics, whereas inadequate technical skills limit the range of tactical solutions⁷. Water polo technique has undergone an entire range of development phases to become what we know today⁷. The technical structure of water polo techniques is very complex and it contains a wide range of performance possibilities, which relate to unique features within the game.

A number of current published studies have used objectively measurable indicators of technical activities and efficiency of water polo⁸⁻¹³. Unfortunately, there is a relative paucity of studies on the technical aspects of youth water polo^{12,14,15}. Skilful performance of simple technical elements is nominally a very good basis for acquiring more complex technical elements¹⁵.

In terms of response, the water polo game includes all possible movements. The players use movements to achieve certain tasks: tackling the field of play, evading the guard of the opposing player, and covering or guarding the opposing player. Ball handling includes the following elements of the water polo technique: receiving, passing, dribbling and shooting the ball. For a better overview of technical elements, it is important to classify the playing technique into areas and categories: According Hraste⁷ water polo technique is divided into six areas: (1) technique of basic types of movements in water polo; (2) technique of special types movements in water polo; (3) technique of basic elements of ball handling; (4) ball shooting (passing) technique; (5) defence technique of field players; (6) goalkeeping technique.

Possible problems in the methodological training of water polo players may arise due to the mismatch between biological and calendar ages, which has been reported as far back as the early 1990's¹⁶. In practice, water polo clubs divide young players by calendar age, not by biological age. In such situations, it is desirable to make an exception and compromise when performing certain technical elements and adapt them to the individual, so that development paths are as suitable as possible. Coaches of young water polo players must monitor psychophysical changes and know the methodology of the training process in order to meet the basic prerequisites for quality and continuous work.

The aim of this paper was to determine and explain the expert opinion on the optimal age of acquiring technical knowledge in water polo. The secondary goal was to provide precisely structured methodological guidelines to trainers/experts for training process(es) with younger age teams.

Methods

The sample of participants

The sample consisted of 27 water polo coaches-experts, aged 27 to 61y, from Croatia. As it is known that there are around 140 licensed water polo coaches in Croatia, the sample used in this research includes approximately 38% of the population of water polo coaches in Croatia; so the sample can be considered highly representative of the population of Croatian/European coaches. Since all survey participants attended a water polo seminar held by the first author of this study and were informed that the results of the study would be presented to them in detail, the dropout rate was 0%. Furthermore, participants were informed on the goal of the research and gave written informed consent prior to participation. In addition, trainers were informed that they could quit without any penalties.

The sample of variables

The sample of variables to estimate the optimal age to start learning all the technical elements known in water polo consisted of 39 elements divided into several relatively homogeneous groups. Biomechanical characteristics and use value of each of the listed elements can be found in Hraste⁶. The vast majority of technical water polo elements are known to water polo experts. However, in order to avoid doubts on the part of the coach, several elements of water polo technique were explained in a few sentences.

According to the type of movement, the technique of basic types of movements in water polo is divided into: (1) crawl; (2) backstroke; (3) breaststroke; (4) mixed swimming style; (5) lateral swimming.

The technique of special types of movements in water polo is divided as follows: (1) head up freestyle; (2) head up backstroke; (3) eggbeater; (4) scissors; (5) eggbeater in moving (6) lifting from the water; (7) jump; (8) start; (9) stopping; (10) repositioning of the body in water; (11) feinting.

The technique of basic elements of ball handling is divided as follows: (1) lifting the ball from underneath (2) lifting the ball with gripped fingers; (3) lifting the ball from above; (4) lifting the ball with the grip of the hand and forearm; (5) stopping and controlling the ball (6) catching the ball; (7) ball transfer from one place to another; (8) dribbling the ball.

The ball shooting (passing) technique is composed of the following elements: 1) basic shot; (2) basic shot from movement; (3) basic shot after popping up the ball; (4) basic shot with a previous turn of the body; (5) *backhand shot*; (6) *backhand shot* from movement; (7) *backhand shot after catching a dry pass*; (8) wrist only *backhand* shot; (9) layout shot; (10) sweep shot; (11) sweep shot by rolling the body; (12) wrist sweep shot; (13) push shot or screw shot; (14) the pop-up shot or t-shot; (15) deflection shot.

Respondents filled out a newly constructed questionnaire asking them to identify the optimal age to start learning all the above-mentioned technical elements of the water polo game. Respondents had the opportunity to choose one of the seven offered options for each technical element for the optimal start of water polo education in the technical segment. The first age option offered was ten years, that is, the first year of inclusion of young water polo players in water polo training. It is at this age that water polo training starts in the clubs of countries where water polo is currently the most developed (Croatia¹⁷, Italy¹⁸ etc.). The last predicted option for starting to learn certain water polo techniques is the seventh year of playing water polo, i.e. the age of sixteen.

Data processing methods

For each item of the measuring instrument, the parameters of descriptive statistics: arithmetic mean (M), standard deviation (SD), median (MED), and minimum (MIN) and maximum (MAX) were calculated. The reliability of the measuring instrument was calculated by the test-retest method. Pearson's correlation coefficient between test and retest was taken as a measure of reliability. In order to assess content validity, and define underlying structure, exploratory strategy of factor analysis together with Guttman-Kaiser criterion for detection of number of real-life existing factors and *Varimax* *Raw* rotation was applied. That is due to the fact that factor analyses are performed by examining the pattern of correlations or covariances between the observed measures and it is assumed that variables measure that are highly correlated are most likely influenced by the same underlying factors¹⁹. Type I error was set to 5%. All calculations were performed using statistical analysis data system "Statistics for Windows" ver.13.0.

Results

During the preliminary validation of the measuring instrument, four water polo coaches were contacted and some details were clarified, and the final form of the questionnaire was constructed. The reliability of the measuring instrument was tested by the test-retest method on the whole sample and for all observed categories of water polo game the correlation coefficient between the test and the retest was high: .85-1.00 ($P < .05$). Additionally, for all observed variables, the arithmetic mean, standard deviation,

median, mode, minimum and maximum value were calculated. Table 1 shows the basic descriptive indicators for the variables of the technique of basic types of movements in water polo, special types of movements in water polo, the technique of basic elements of ball handling in water polo, of the ball shooting (passing) technique

The results in Table 1 indicate that crawl, backstroke, and breaststroke begin to be learned at the beginning of the first educational year (M-10.00; M-10.07; M-10.00). Other techniques of basic types of movements in water polo begin to be learned in the second half of the first educational year (M-10.63; M-10.81). According to the results, it can be noticed that head

Table 1. Results of descriptive statistics for all water polo technical variables: Arithmetic mean $\pm$ standard deviation (M $\pm$ SD), Median (Med), modal value (Mod), Minimum value (Min), Maximum value (Max).

Technical element	M $\pm$ SD	Med	Mod	Min	Max
CRAW	10.00 $\pm$ 0.00	10	10	10	10
BAST	10.07 $\pm$ 0.38	10	10	10	12
BRST	10.00 $\pm$ 0.00	10	10	10	10
MSS	10.63 $\pm$ 0.63	11	10	10	12
LS	10.81 $\pm$ 0.74	11	11	10	13
HUS	10.63 $\pm$ 0.49	11	11	10	11
HUB	10.70 $\pm$ 0.47	11	11	10	11
EGG	10.44 $\pm$ 0.51	10	10	10	11
SCI	10.44 $\pm$ 0.51	10	10	10	11
EGGM	10.78 $\pm$ 0.58	11	11	10	12
LIFW	10.89 $\pm$ 0.64	11	11	10	12
JUMP	11.04 $\pm$ 0.76	11	11	10	12
STAR	11.00 $\pm$ 0.78	11	11	10	12
STOPP	11.19 $\pm$ 1.18	11	11	10	16
REBW	11.67 $\pm$ 1.11	12	12	10	15
FEIN	11.44 $\pm$ 1.01	11	11	10	14
LIBU	11.04 $\pm$ 0.81	11	11	10	13
LIFG	11.81 $\pm$ 1.27	12	12	10	16
LIBA	11.59 $\pm$ 1.08	12	12	10	15
LIBH	11.70 $\pm$ 0.84	12	12	10	16
SCB	11.37 $\pm$ 0.73	11	11	10	13
CATB	11.07 $\pm$ 0.81	11	11	10	13
BATR	11.26 $\pm$ 0.68	11	11	10	13
DRIB	10.96 $\pm$ 0.71	11	11	10	12
BS	10.96 $\pm$ 0.71	11	11	10	12
BSM	11.30 $\pm$ 0.87	11	11	10	13
BSPB	11.78 $\pm$ 0.80	12	12	10	13
BSTB	11.96 $\pm$ 0.81	12	12	10	13
BHS	12.37 $\pm$ 0.88	12	12	11	14
BHSM	12.81 $\pm$ 1.11	13	13	11	16
BHSC	12.96 $\pm$ 1.06	13	13	11	15
BHSW	13.19 $\pm$ 1.08	13	13	11	16
LAYS	13.11 $\pm$ 1.28	13	13	11	16
SWS	12.74 $\pm$ 1.10	12	12	11	16
SWSR	12.89 $\pm$ 1.12	13	12	11	16
SWSW	13.22 $\pm$ 0.89	13	13	12	16
PS	12.93 $\pm$ 1.07	13	13	11	16
PUS	12.89 $\pm$ 0.75	13	13	11	14
DES	12.89 $\pm$ 0.70	13	13	12	14

Legend: CRAW-crawl, BAST-backstroke, BRST-breaststroke, MSS-mixed swimming style, LS-lateral swimming, HUS-head up freestyle, HUB-head up backstroke, EGG-eggbeater, SCI-scissors, EGGM-eggbeater during movement, LIFW-lifting from the water, JUMP-jump, STAR-start, STOPP-stopping, REBW-repositioning of the body in water, FEIN-feinting, LIBU-lifting the ball from underneath, LIFG-lifting the ball with the finger grip, LIBA-lifting the ball from above, LIBH-lifting the ball with the grip of the hand and forearm, SCB-stopping and controlling the ball, CATB-catching the ball, BATR-ball transfer from one place to another, DRIB-dribbling the ball, BS-basic shot, BSM-basic shot from movement, BSPB-basic shot after popping up the ball, BSTB-basic shot with a previous turn of the body, BHS-backhand shot, BHSM-backhand shot from movement, BHSC-backhand shot after catching a dry pass, BHSW-wrist only backhand shot, LAYS-layout shot, SWS-sweep shot, SWSR-sweep shot by rolling the body, SWSW-wrist sweep shot, PS-push shot or screw shot, PUS-the pop-up shot or t-shot, DES-deflection shot

up freestyle, head up backstroke, eggbeater, scissors, eggbeater during training and lifting from the water start learning in the first educational year (M-10.63; M-10.70; M-10.44 ; M-10.44; M-10.78; M-10.89), while lifting from the water, start, jump, stopping, repositioning of the body in water and feinting begin

to be learned in the second educational year (M-11.04; M-11.00; M-11.19; M-11.67; M-11.44). In table 1, it is detailed that except dribbling the ball (M-10,96) all other basic elements of ball handling in water polo belong to another educational period (lifting the ball from underneath M-11.04; lifting the ball with the

Table 2. Factor analysis of expert's opinion of optimal beginning age for learning technical skills in water polo (Expl.Var – variability explained by single factor; Prop.Totl – proportion of variability explained by single factor)

Variable	Factor 1	Factor 2	Factor 3	Factor 4
BAST			-.68	
HUS		-.61		
HUB		-.66		
EGG		-.66		
SCI		-.66		
EGGM			-.59	
LIFW	-.54			
JUMP	-.61			
STAR	-.56	-.63		
STOPP				.69
REBW			-.61	
FEIN	-.55			
LIBU	-.55			
LIFG			.60	
LIBA				.66
LIBH				.62
SCB	-.65			
CATB	-.69			
BATR	-.69			
DRIB	-.78			
BS	-.77			
BSM	-.77			
BSPB			.64	
BSPB	-.65			
BHS	-.56			
BHSM			-.59	
BHSC				-.63
BHSW		.51		-.47
LAYS		.57		
SWS		.59	-.50	
SWSR	-.59		-.50	
SWSW		.67		
PS	-.66			
PUS	-.63			
DES			.55	
Expl.Var	10.77	5.90	5.42	3.32
Prp.Totl	.31	.17	.15	.09

Legend: BAST-backstroke, HUS-head up freestyle, HUB-head up backstroke, EGG-eggbeater, SCI-scissors, EGGM-eggbeater during movement, LIFW-lifting from the water, JUMP-jump, STAR-start, STOPP-stopping, REBW-repositioning of the body in water, FEIN-feinting, LIBU-lifting the ball from underneath, LIFG-lifting the ball with the finger grip, LIBA-lifting the ball from above, LIBH-lifting the ball with the grip of the hand and forearm, SCB-stopping and controlling the ball, CATB-catching the ball, BATR-ball transfer from one place to another, DRIB-dribbling the ball, BS-basic shot, BSM-basic shot from movement, BSPB-basic shot after popping up the ball, BSTB-basic shot with a previous turn of the body, BHS-backhand shot, BHSM-backhand shot from movement, BHSC-backhand shot after catching a dry pass, BHSW-wrist only backhand shot, LAYS-layout shot, SWS-sweep shot, SWSR-sweep shot by rolling the body, SWSW-wrist sweep shot, PS-push shot or screw shot, PUS-the pop-up shot or t-shot, DES-deflection shot

finger grip M-11.81; lifting the ball from above M-11.54; lifting the ball with the grip of the hand and forearm M-11.70; stopping and controlling the ball M-11.37; catching the ball M-11.07; ball transfer from one place to another M-11.26. According to table 1, coaches teach the ball shooting (passing) technique in four different educational years. In the first year the basic shot (10.96) is taught, while in the second year the basic shot from movement (11.30), the basic shot after popping up the ball (11.78) and the basic shot with a previous turn of the body (11.96). In the third year, backhand shot (12.37), backhand shot from movement (12.81), backhand shot after catching a dry pass (12.96), sweep shot (12.74), sweep shot by rolling the body (12.89), push shot or screw shot (12.93), the pop-up shot or t-shot (12.89) and deflection shot (12.89) are taught. In the fourth educational year, wrist only backhand shot (13.19), layout shot (13.11) and wrist sweep shot (13.22) are taught.

Prior to the analysis of the latent structure, it should be noted that four fundamental variables, likely due to the very small variability of experts' answers, were not saturated to the any factor.

Four relatively independent latent dimensions were isolated by factor analysis and named as: (1) *Basic ball manipulation, basic shots and explosive movements*; (2) *Basic water polo movements and shots from the central forward position*; (3) *Complex movements, ball manipulation and shots*; (4) *Activity for the preparation and execution of the most demanding backhand shots* which explain 31%, 17%, 15%, 9% of the variability of manifest space, respectively.

Discussion

Observing the results of the standard deviations, it can be seen that the values of standard deviation increase with the biomechanical complexity of the variable. Based on the results of the means, it is evident that coaches likely prefer to begin teaching all swimming techniques, specific water polo movements in part, and focus on only two basic elements with the ball in the first year of education. In the second year of learning technical water polo elements, the curriculum should encompass the remaining specific water polo movements, ball manipulation elements, and simple shooting techniques. It is assumed that in the third and fourth years of study, young water polo players continue their education by mastering the complex and ultimately the most demanding shots. There is a possibility that coaches implicitly follow didactic principles when structuring the dynamics of learning technical elements in water polo, which is fundamentally important. The established sequence for initiating the learning of technical elements in water polo can serve as a guide for water polo coaches working with young players during the training process. The first latent dimension can be named as *Basic ball manipulation, basic shots and explosive movements*. First latent dimension, which is responsible for 31% of variability of items, as being determined by variables: lifting from the water; jump; start; feinting; lifting the ball from underneath; stopping and controlling the ball; catching the ball; ball transfer from one place to another; dribbling the ball; basic shot; basic shot from movement; basic shot with a previous turn of the body; *backhand shot*; sweep shot by rolling the body; push shot or screw shot; the pop-up shot or t-shot. This latent dimension is defined by the variables' characteristic of the basic technique of water polo in the form of ball manipulation, shots and explosive movements. It is plausible that the experts estimated that the mentioned variables were at the top of the hierarchical structure

at the optimal start of learning technical skills in water polo. The above variables essentially represent a good basis for continuing water polo education.

The factor named *Basic water polo movements and shots from the central forward position* represents the second latent dimension, and it is determined by the following variables: head up freestyle; head up backstroke; eggbeater; scissors; start; wrist only *backhand* shot; layout shot; sweep shot; wrist sweep shot. The second latent dimension is responsible for 17% of variability of items. If the first and second latent dimensions are analysed, there is an assumption that can lead us to an expert opinion that young water polo players can start playing basic water polo after learning the skills that include the variables from the first two factors. It is likely that the second latent dimension represents an upgrade of the first latent dimension, all with the purpose of playing the first official water polo matches.

The third latent dimension, which is responsible for 15% of variability of items, as being determined by variables: backstroke; eggbeater during movement; repositioning of the body in water; lifting the ball with the finger grip; *backhand shot* from movement; sweep shot; sweep shot by rolling the body; deflection shot, can be interpreted as *Complex movements, ball manipulation and shots*. Considering the complexity of the technical performance of the mentioned variables, the experts likely placed the mentioned variables only in the third place in the hierarchical structure of the optimal beginning of learning technical skills in water polo. Most of the mentioned technical performances can be learned after the well-learned basic skills listed in the first two latent dimensions. Learned technical performances of greater complexity enable a game with more tactical possibilities, which corresponds to the older age of young water polo players compared to the beginning of water polo education. Finally, the fourth latent dimension was named as an *Activity for the preparation and execution of the most demanding backhand shots*. The following variables mostly belong to the fourth factor: stopping; lifting the ball from above; lifting the ball with the grip of the hand and forearm; *backhand shot after catching a dry pass*; wrist only *backhand* shot. Experts likely estimated that the preparation and execution of the most demanding screws represents the last link in the comprehensive technical education of young water polo players. This is entirely plausible, considering the high demands in performance of most of the mentioned variables. Additionally, it may be considered that part of the technical performance belongs to specialization in water polo, which is done much later compared to the age that belongs to the beginning of water polo education.

The results of the present research confirmed that this is a reliable and valid questionnaire for determining the optimal beginning age for learning technical skills in water polo. In addition, the questionnaire was successfully structured, according to modelled technical elements depending on the age of the young water polo players.

Moreover, the results indicate the high level of agreement of almost all coaches that all swimming techniques should begin to be learned at the beginning of the first educational year in water polo, which is logical because these are the most basic techniques in water polo, while slightly more complex basic types of movements in water polo should be learned at the end of the first year of learning in water polo. Therefore, the selection of teaching is in accordance with the principles of the didactic principles^{1,2}. It is possible that the trainers, in determining the order of teaching the technique of special types of movements and basic elements of ball handling in water polo, were also guided

by the above principles. Namely, simpler elements that included only one action were learned in the first educational year, while in the second educational year more complex elements were learned that included a combination of two or more actions. The results of this study indicate that the coaches logically estimated that the four basic shots should start to be taught according to the didactic principles^{1,2}, from simpler and lighter to more complex and difficult ones. By distributing elements of the ball shooting (passing) technique according to the complexity in four years, the possibility of injuring young water polo players can be ameliorated, which is in line with the recommendations that it is very harmful to start early specialization in sports⁵. Except higher rates of injury, risks of early sports specialization include increased psychological stress and quitting sports at a young age⁵. Generally, only proper periodization and methodically correct training in young water polo players and other athletes can lead to the desired effects^{15,20}. Since the questionnaire was completed by a sample of experienced and educated water polo coaches, it is likely that answers were guided, or at least influenced, by examples of good practice, expert opinion, and developmental characteristics of children³.

Practical applications

The results of this research, which should be included in the curriculum of the training process, could facilitate all young water polo players to reduce injury risk, have a longer playing career, and achieve proper growth and development.

Conclusions

In the present study, for the first time, the coaching opinion on the optimal age of learning 39 elements of water polo technique, which are classified into four areas, was determined and explained. We found that the coaches mostly agree that water polo elements should be taught according to basic didactic principles. This means that the technique of water polo is taught from simpler elements to more complex and from easier to more difficult.

Future research should seek to increase the number of trainers, with ranging levels of coaching experience, playing experience, and qualification, involved in this work, so to gain deeper insight into the understanding and utilization of didactic principles in water polo.

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Ethical Committee approval

The use of these data did not require approval from an accredited ethics committee, as they are not covered by data protection principles, i.e., they are non-identifiable, anonymous data collected through an anonymous questionnaire.

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Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Topic

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Declaration if used ChatGPT

We don't used ChatGPT.

Author-s contribution

Conceptualization, M.H. and I.J.; methodology, M.H., I.J. and C.C.T.C.I.J.; software, I.J.; validation, M.H., I.J. and C.C.T.C.; formal analysis, M.H. and I.J.; investigation, M.H.; resources, M.H. and I.J.; data curation, M.H. and I.J.; writing—original draft preparation, M.H., I.J. and C.C.T.C.; writing—review and editing, J M.H., I.J. and C.C.T.C.; visualization, M.H., I.J. and C.C.T.C.I.J.; supervision, C.C.T.C.; project administration, M.H. All authors have read and agreed to the published version of the manuscript.

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