MOTOR COORDINATION TEST AS AN INDICATOR FOR SKATING PERFORMANCE IN ICE HOCKEY FOR PRE-PUBERTY CHILDREN

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ABSTRACT

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The purpose of this study was to investigate the suitability of the KTK-test as an indicator for ice hockey performance in pre-puberty children. Skating is the most important fundamental skill in ice hockey and the KTK-test has been proved to be valid test for motor coordination. Subjects were 34 (mean 10 yrs 10 mos ± 6 mos) boys from Juniori-KalPa and 31 completed the tests.

The KTK MQ (tot) correlated significantly with skating agility test $r = -0.527$ ($p \leq 0.01$) and one leg hopping (MQ(OLH)) showed the highest correlation between the skating agility test ($r = -0.660$, $p \leq 0.01$). The skating agility test showed a significant correlation ($r = 0.555$, $p \leq 0.01$) between the 30 m skating test. In group analyses of the KTK-test there was a highly significant difference between groups 4 and 2 (3.44±1.02 s., $p \leq 0.01$) in the skating agility test. In group analyses of the skating agility test there was a significant ($p \leq 0.01$) difference between groups 1 and 3 in KTK MQ(tot.) (14.4±4.35), MQ(OLH) (15.4±3.99) and MQ(JS) (14.4±4.19) and ($p \leq 0.05$) with MQ(MS) (14.9±6.00). In groups analyses there was no significant difference between the KTK-groups or the skating agility groups in 30 m skating test.

These results indicate that the KTK-test is a suitable indicator for ice hockey skating in pre-puberty children. Players with higher motor coordination are more capable to perform in ice hockey skating as well. The skating agility test is valid and useable for evaluating skating performance.

Key words: motor coordination, skating, pre-puberty, ice hockey, KTK-test, agility

TABLE OF CONTENTS

1 INTRODUCTION 4
2 SKATING IN ICE HOCKEY 5
2.1 Forward and backward skating 6
2.1.1 Pushing phase in stride 7
2.1.2 Gliding phase in stride 8
2.1.3 Recovery phase in stride 8
2.2 Crossovers, stopping and turning manoeuvres 9
2.2.1 Crossover skating 9
2.2.2 Stopping techniques 9
2.2.3 Turning manoeuvres 10
3 MOTOR COORDINATION 13
3.1 Balance skills 16
3.2 Basic movement skills 16
3.3 Object control skills 17
3.4 Testing motor coordination 17
4 PUBERTY 19
4.1 Identification of biological age 19
4.1.1 Growth spurt 21
4.1.2 Maturation of the reproductive system 22
4.2 Physical development during puberty 22
4.2.1 Growth 22
4.2.2 Strength development 23

4.2.3 Motor coordination ... 25
4.3 Characteristics of pre-puberty in sports ... 26
5 PURPOSE OF THE STUDY ... 27
5.1 Research objectives ... 27
5.2 Hypotheses ... 27
6 METHODS ... 28
6.1 Subjects ... 28
6.2 Study design ... 28
6.3 Maturation level ... 28
6.4 Body coordination test pattern ... 28
6.5 Skating tests ... 32
6.5.1 30 m skating test ... 32
6.5.2 Skating agility test ... 33
6.6 Statistical analyses ... 34
7 RESULTS ... 35
7.1 Descriptive statistics ... 35
7.2 Correlations ... 38
7.3 Group analyses ... 41
7.3.1 KTK Groups analyses ... 41
7.3.2 SAT Group analyses ... 43
8 DISCUSSION ... 48
9 REFERENCES ... 52

1 INTRODUCTION

In ice hockey skating ability is the most important skill to master. Skating ability gives a player advance to perform smaller turns, faster starts and a faster skater can win an opponent on chasing the puck. The ability to skate effectively is physically really a demanding task. The ice surface is really slippery and balancing on top of the thin blades requires good balance skills. Effective skating is a well controlled continuous action of movement which requires good coordination for all extremities. Lower limb strength is an important factor in skating speed and that may give advantage for a player who is earlier maturated. The player who is maturing later might have better motor coordination for skating, but is left out from the development programs, because he is losing battles and in skating competitions for early matured peers.

Motor coordination is developed during the early childhood before the age of seven. A person is, however, able to learn motor skills during the whole life span. Motor coordination is somehow stable after it has stabilized. Motor coordination has been proven to have effect on learning motor skills. With better motor coordination a person can learn new skills much easier. Motor coordination is coordination of lower and upper limbs, torso, head and synchronizing all body movement appropriately. A person might have excellent motor coordination but maturation has not yet started. This delay might affect on athletes possibilities to develop in a team, if the coach is not aware of differences in individuals biological age in a team.

There have been studies which have focused on finding an off-ice test which is suitable to indicate skating ability. Mostly these studies are conducted in mature or almost mature players and test of off-ice performance have been for physical characteristics. The purpose of this study is to investigate the suitability of a motor coordination test (KTK-test) for indicating skating performance for pre-puberty children.

2 SKATING IN ICE HOCKEY

The characteristics of skating and gliding makes ice hockey a fastest game played (Haché 2002, 17). Westerlund and Summanen (2000, 24) had a vision that ice hockey will develop to become even faster. To be able to perform fast and without any delay during the game, skating ability is the most important skill in ice hockey (Haché 2002, 60, Farlinger & all, 2007, Federolf & all. 2007, Cady & all. 1998, 1, IIHCE 2014, Väliaho 2006, Krause & all. 2012). Burr & all. (2008) support the fact that skating is really important, but they raise other important factors such as body size, muscle strength (Farlinger & all. 2008), coordination and endurance capacities. Coordination is essential to produce functional kinetic chain on skating performance (FIHA 2013). Ice hockey skating requires a lot of skill and it involves many different components (Behm & all. 2005) and ice hockey is physically very demanding sport (Gilenstam & all. 2011, Nightingale & all. 2011).

Skating ability is a fundamental skill in ice hockey and according to Paananen & Räty (2002) it should be emphasised in youth. With a solid skating ability the player is able to perform manoeuvres which help in game situations. Important physical characteristics of the skating fundamentals are versatility, strength, speed and endurance. Skating speed increases during maturation (Blatherwick 1992, 17). Technical fundamentals are posture with the head high, in order to be able to observe playing area, reciprocal rhythmical forward directed arm and leg swing, knee angle of pushing leg ~90º, alignment of upper body and pushing leg tibia, (figure 1). (IIHCE 2014., Stamm 2010, 38-40.) To get a proper posture in ice hockey skating, a player should have bent knees and ankles; forward lean from the waist, alignment of eyes should be toward the playing area, proper alignment of upper and lower body and proper balance distribution on skates. (Cady & all. 1998, 6, Stamm 2010, 8-9.)

FIGURE 1: Proper skating posture from side (left) and from front (right). (IIHCE 2014)

2.1 Forward and backward skating

Most commonly in an ice hockey game a player is skating forward (Stamm 2010, 41) and 60 - 80 % of skating involves turning by gliding or crossover (Smith & all. 2013). There are differences between attacking and defensive players which skating skill they use during the game, but every player is required to perform all different skating skills. Push off technique for forward and backward skating is similar; only reverse (Stamm 2010, 80). It is really important to use the edges of skates to produce power on skating (Noorholf & all. 2013, Stamm 2010, 38). Edges should push the ice on approx. 45 º.

Basic elements for effective skating are similar to many other sports. These elements are wind up, release, follow through and accurate timed weight transfer. Specific action what is needed in effective skating is quick recovery of pushing leg, in order to be ready for a new push. (Stamm 2010, 33.)

Effective skating requires constant transfer of body weight. Skating is a constant variation of the push-glide sequence and transformation of weight to working leg is really important in order to achieve more speed effectively. In order to gain more speed every push should initiate beneath the centre of gravity of player. (Stamm 2010, 39.)

2.1.1 Pushing phase in stride

The pushing phase is used to gain more speed. It is important to load all weight on the pushing leg before stride (Stamm 2010, 39). At the beginning of a stride the activation of gluteus and thigh muscles is important to achieve pushing forward force. (IIHCE 2014.) According to Noordhof & all. (2013) it is more important to have an effective push-off phase than solid power to skate faster. Skating requires good technique in order to be able to use the power efficiently. Stamm (2010, 41) emphasises also the importance of proper skating technique. Even though Noordhof & all. (2013) were investigating speed skating the push-off phase is rather the same than what is used in ice hockey. Every stride in ice hockey is technically alike for a player, but the difference is on gliding phase. Technical executions of leg drive, weight shift, leg recovery are basically the same in every stride (Stamm 2010, 43).

The push-off phase begins in a wind up position, which Stamm (2010, 42) calls V-diamond. The V-diamond position is illustrated in figure 2. In the beginning of the wind up phase skates are located directly under the body and heels of the skates are located closely together.

The actual push-off requires a player to move whole body weight against the pushing edge. The proper execution of the push begins from the heel of the inside edge and finish with the push of the toe of the inside edge (Stamm 2010, 43). Skating requires cooperation of both legs and while one leg is pushing the other leg is becoming to a gliding leg. It is really important that the pushing leg will reach full extension. Only with the full extension all the power is useable for forward movement. At the end the fully extend leg is to be lifted off the ice and recovered under the body. (Stamm 2010, 45.)

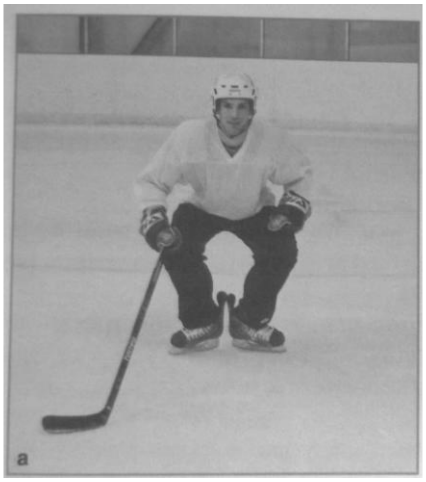

FIGURE 2: V-diamond posture at the beginning of the stride (Stamm 2010, 42).

2.1.2 Gliding phase in stride

The gliding phase is a simultaneous action on a non-pushing leg as the pushing leg is executing the push-off phase. The gliding phase has an important role in keeping up the velocity of skating. With proper gliding technique skating is more efficient. At the beginning gliding takes place on outside edge of the gliding skate and it makes the outward curve. The skate is gliding on outside edge only for a short period and then gliding continuous on flat part of the edge. (Stamm 2010, 49.)

2.1.3 Recovery phase in stride

When the leg returns under the body, the skate should return to the V-diamond posture for momentum and then immediately pass by it. The returning leg should take from outside to the inside bath with knee and toes turned outside. (Stamm 2010, 48).

2.2 Crossovers, stopping and turning manoeuvres

During the ice hockey game a player is required to perform different kinds of manoeuvres on skates. A player has to be able to change rapidly skating direction, skate on angular path and to be able to stop. These manoeuvres require motor coordination of the body, balance and agility.

2.2.1 Crossover skating

Crossover skating is used to accelerate and moving on the curves. Crossover skating helps a player to change the direction and win the opponent on 1-on-1 situations. (Stamm 2010, 99.) In crossover skating the outside skate is passing the inside skate. Crossover skating requires that both skates have edges on ice. The inside skate is on its outside edge and the outside skate is on its inside edge. It is important that a player is using both legs on crossover in order to generate maximal speed. (Stamm 2010, 100.)

For a player to manage skate effectively on the curves he has to overcome the inertia. To be able to beat the inertia it is crucial for the skater to lean strongly inward the curve with lower body and to keep the balance he should make counter movement with upper body. (Stamm 2010, 100) In all playing situations it is important that a player can keep his shoulder parallel to ice surface.

2.2.2 Stopping techniques

There are several different techniques to stop in ice hockey. However, hockey stop is mainly used during the game situations because it is a sudden, well balanced and it allows a rapid change of direction (Stamm 2010, 174). Hockey stop requires a player to turn ones skates 90 º against skating direction. Proper execution of hockey stop on its final phase is illustrated in figure 3. It is important that during the stop a player is able to keep his vision on the playing area.

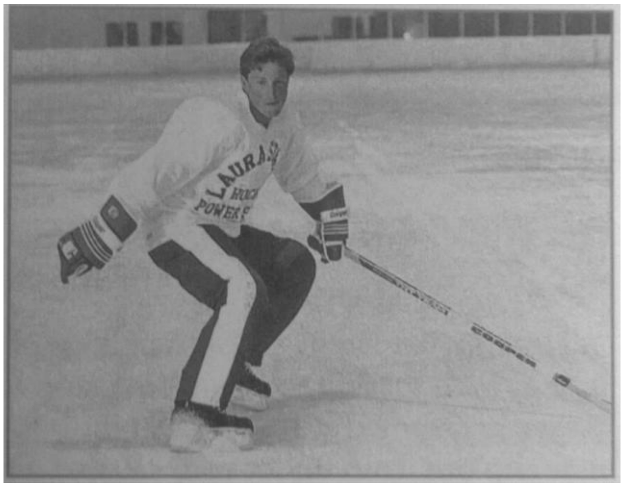

FIGURE 3: Final phase of hockey stop. (Stamm 2010, 175.)

2.2.3 Turning manoeuvres

Proper and effective turning techniques are crucial in a game situation where players should change the direction of skating (Cady & all. 1998, 103, Stamm 2010, 189). Every turning manoeuvre requires rotation of the entire body and change of the feet during the turn (Stamm 2010, 189). Chambers (1981) divides the turning techniques to three different techniques, where IIHCE (2014) divides turnings to six more specific categories. Because ice hockey has become faster, the ability to turn quickly at high speed is the most important skill to master (Cady & all. 1998, 110).

Two skate quick turn. This requires skater to turn both skates at the same time to the same direction. Body should be bend little bit to the inside turn. Weight should be divided on blades of both skates. (Chambers 1981, 3.) IIHCE (2014) emphasises in addition to previous weight lowering at the beginning of the turn and the leading role of the inner skate. Shoulder line should stay parallel to ice surface during the turn. Stamm (2010, 215-216) divides this turn in two phases entering and the exiting phases of the turn. At the entering phase it is important to have strong edges on both skates and in exiting phase require a powerful and fast crossover skating.

Forward to backward turn. This requires to pivot the blade of the inside skate on the ice. The pushing phase is performed first with the outside leg. (Chambers 1981, 3). When turning from forward skating to backward skating the pushing leg has a major role, it leads the turn and hip opening at the beginning and finishes the turn with first push of backward skating (IIHCE 2014). At the preparation phase of the turn a player should release weight and rotate upper body 180 º (Stamm 2010, 191).

Backward to forward turn. This requires to turn the inside skate outward and then push off with the outside leg. Rotation of the upper body should happen in the direction of the turn. (Chambers 1981, 3). IIHCE (2014) emphasis in addition to prior, that the leg should open to V-form and lowering weight during the turn is important. Stamm (2010, 191) points out that in the preparation phase a player should lower weight and rotate upper body 180 º.

Defender turn. This is somehow a modification of forward to backward turn and it has three different styles to execute it. 1) Heels first into the turn, where lowering weight at the beginning, turning heels to the direction of the movement, legs shoulder wide apart, shoulder line parallel to the ice surface and balance is in inside edge of the outer skate and outer edge of the inside skate. 2) Toes first into the turn begins with two skate quick turn, but after midpoint of the turn is reached the turning technique is similar than the heels first turn. 3) Turn with stop begins with lowering weight quickly and placing both skates sideways and stops the movement. After the stop skating continues backward. A player should perform these different styles according to playing situation. Using this tuning technique a player should keep vision all the time on the game. (IIHCE 2014.)

Winger turn. This is a technique were a player turns from forward skating to forward skating and keeps the vision on the game during the whole turn. At the beginning of the turn a player should lower his weight, turn heels first, keep shoulder line parallel to ice surface and legs shoulder wide apart. The pushing phase starts with inside edge of the outer skate. (IIHCE 2014.) This type of turns is mainly used by forwards who play as a winger.

U-turn. This is used when a player is chancing skating direction from backward to forward and changes the direction of movement at the same time. This turn begins with rapid lowering of weight and leaning upper body strongly to the direction arrival. Then opening the hip and placing the weight to the inside edge of one of the skates and glide with that edge. At the end of the turn a player performs forceful push with gliding skate inside edge. (IIHCE 2014.)

3 MOTOR COORDINATION

Motor coordination is organized activation of muscles in order to achieve the desired goal and it involves patterns of the head, body and/or limb movements (Magill 2003, 53-54). Motor coordination is coordinated work of muscles, nerves and sensory organs (Kiphard 1970, 11). Motor control is highly hierarchy and the brain and regulation mechanisms controls at high level, where the spinal cord controls at a lower level (Kauranen 2011,119). Optimal motor coordination to perform a desired task requires proper muscle strength, activating proper muscles and ability to fast activate and inactive muscles (Kiphard 1970, 11).

Coordination is used mainly to describe skilful performance, even though not so skilful action needs also motor coordination. Defining motor coordination, it is important to understand that all movements are under the environmental influence. (Magill 2003, 54, Jaakkola 2000, 150.) Motor coordination is used to perform physical activity in order to achieve the desired goal. There are individual variations in movement adjustments. (Magill 2003, 5.) Individual motor capacity cannot be explained with only one factor, while motor performance is coordination of tens of different factors (Kauranen 2011, 205).

There is evidence that motor coordination is somehow stabile through the life span. (Vandorpe & all. 2011, Vandorpe & all. 2012a, Vandorpe & all. 2012b.) There is a window of opportunity to enhance motor coordination before the age of six (Vandorpe & all. 2012a). If basic movement skills are enhanced during this window of opportunity, it is easier for a child to learn new more specific skills which are needed in sport (Kalaja 2012, 14).

Taxonomy of motor abilities was designed to identify the fewest possible ability categories. In taxonomy human motor abilities were divided in 11 categories, which are shown in table 1. (Magill 2003, 44). Magill (2003, 43-45), in addition to those eleven, introduced five abilities which are: 1) static balance, 2) dynamic balance, 3) Visual acuity, 4) visual tracking and 5) eye-hand or eye-foot coordination. Basic motor skills can be divided on balance, basic movement and object control skills (Kalaja & all. 2009, 37).

Every person has motor abilities, but the amounts of each differ in a person (Magill 2003, 45). Morrow & all. (2011, 280) emphasise that motor skills are highly dependent of the abilities person has. To be able to modify motor abilities to motor skills, a person needs a lot of repetitions and sufficient feedback (Maslovat & all. 2010, 222). Motor skills are sustainable after they are adopted (Kalaja & all 2009, 37). Basic motor skills are important for everyday life and as a building block to learn more difficult skills needed e.g. in sports (Vandorpe & all. 2011, Vandorpe & all. 2012a, Westendorp & all. 2011). At the beginning a person is using basic motor skills to achieve the goal, but when he adopts more skill, the training must be more specific (Kalaja 2012, 13) and training should have more quality (Maslovat & all. 2010, 223). It is important to know the skills person already has in order to develop new skills, because skills which are already learned are a foundation for new skills (Maslova & all. 2010, 222). There is evidently a gender difference in motor development during the whole childhood (Raundsepp & all. 1995).

Table 1. Perceptual motor ability (modified from Magill 2003, 44)

Ability category	Definition
Multilimb coordination	Ability to co-ordinate movements of number of limbs simultaneously
Control precision	Ability to make rapid and precise movement adjustments of control devices involving single arm-hand or leg movements; adjustments are made to visual stimuli
Response orientation	Ability to make rapid selection of controls to be moved or the direction to move them in
Reaction time	Ability to respond rapidly to a signal when it appears
Speed of arm movement	Ability to rapidly make gross, discrete arm movement where accuracy is minimized
Rate control	Ability to time continuous anticipatory movement adjustments in response to speed and/or direction changes of a continuously moving target or object
Manual dexterity	Ability to make skilful, arm-hand movements to manipulate fairly large objects under speeded conditions
Finger dexterity	Ability to make skilful, controlled manipulations of tiny objects involving primarily the fingers
Arm-hand steadiness	ability to make precise arm-hand positioning movements where strength and speed are minimized; includes maintaining arm-hand steadiness during arm movement or in a static position
Wrist, finger speed	Ability to make rapid and repetitive movements with the hand and fingers, and/or rotary wrist movements when accuracy is not critical
Aiming	Ability to rapidly and accurately move the hand to a small target

3.1 Balance skills

Balance is the ability to sustain and control posture with muscle activity and with sensory information (Kauranen 2011, 180). Balance skills can be divided to static balance and dynamic balance (Kalaja & all. 2009, 37, Magill 2003, 43). In several studies girls have better results in balance skill tests than boys, but there is a difference in static and dynamic balance (Kalaja 2009, 43).

To perform proper skating in ice hockey the balance and stability are essential factors, because skater stands on thin edges (Behm & all. 2005, Stamm 2010, 11, Krause & all. 2012). For young players, the balance is more important than older ones in skating performance, because skating requires more specific skills with developed players (Behm & all. 2005).

3.2 Basic movement skills

Human movement involves displacement of the body or body part from one place to another. (Kauranen 2011, 199) There are nine basic movement skills which are: 1) walking, 2) running, 3) jumping, 4) jumping with one leg, 5) rhythmical jumping, 6) galloping, 7) gliding, 8) leaping and 9) climbing (Kalaja & all. 2009, 37).

Individuals have different styles in their basic movement, for example, walking style, but human develops the style which is an economical way of movement. Basic movement is movement skill which a child can learn without any specific training. (Kauranen 2011, 202, Maslovat & all. 2010, 221)

3.3 Object control skills

Eye-hand or eye-foot coordination is an important ability in object control. To be able to control the object visual feedback gives information for hand about the size and shape of the object (Kauranen 2011, 240). Object control skills consists 1) throwing, 2) catching, 3) kicking, 4) capturing, 5) striking, 6) hitting on air, 7) bouncing, 8) rolling and 9) kicking on air (Kalaja & all. 2009, 37). Several studies indicate that boys have got better results in object control tests (Kalaja & all. 2009, 43). Kalaja (2012, 13) makes a difference between gross motor skills and fine motor skills in object control.

3.4 Testing motor coordination

Motor coordination tests have a long history in analysing human performance. Assessment of psychomotor abilities is really important in coaching (Morrow & all. 2011, 313.). Some motor coordination tests were developed in order to find out learning problems and possible abnormalities on child's development (Kiphard 1979, 26). Kalaja (2012) used on his doctoral thesis test protocol which was designed for fundamental movement skills. He used flamingo test for static balance; rolling test for dynamic balance; 5-jump leaping test; shuttle-run test; rope jumping with one leg; accuracy throwing and figure-8 dribbling for manipulative skills. Vandorpe & all (2011) evaluated the suitability of German test battery Körperkoordinations Test für Kinder (KTK) as an instrument to assess children's gross motor coordination. Their conclusion was that KTK-test is suitable and reliable test for children. They also suggested that this test battery might be useable for talent identification on sports. KTK-test has been found to predict performance capacity on elite gymnastics (Vandorpe & all. 2012b). Children who scored high MQ-results, especially on moving sideways test, were performing better in competitions 2 years later (figure 4).

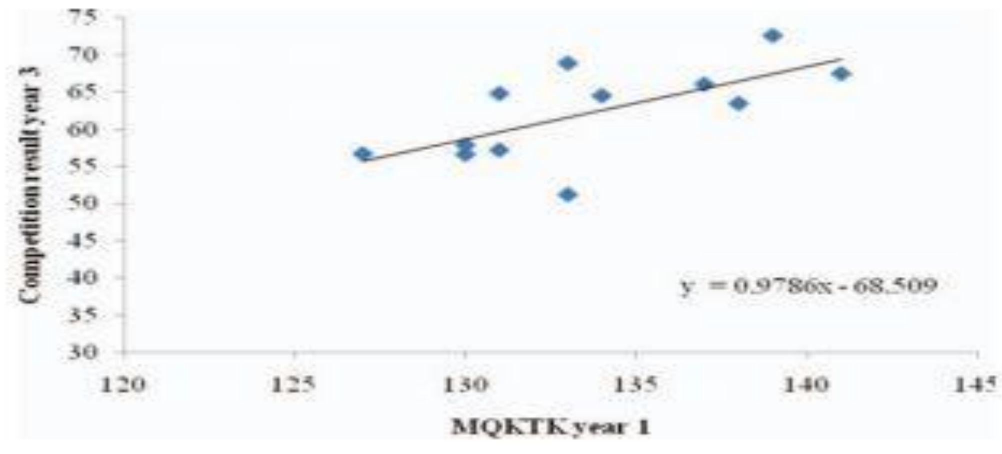

Figure 4: Correlation between MQKTK versus performance result at elite gymnastics competitions after 2 years (Vandorpe & all. 2012b).

KTK-test consist four different subtest; 1) walking backward 3 times on 3 different wooden rods which are decreasing on width 2) one leg jumping over a foam obstacle increasing height with 5 cm 3) jumping sideways over small obstacle for 15 s and 4) moving sideways over wooden platforms in 20 s. Overall summation of each subtest are transformed into age- and gender-specific motor quotients and resulting a general motor quotient (Kiphard 1979, 49).

4 PUBERTY

Puberty is the stage of human development where final maturation of the reproductive system, bone and parts of body will grow fast and final development of height is accomplished (Hakkarainen 2009, 76-77). The puberty begins with the activation of the hypothalamic-pituitary-gonadal axis and it will end with reproductive capability and adult body composition. Two main indicators for puberty are growth spurt and appearance of the secondary sex characters. (Abbassi 1998, 507.) During puberty a child´s body is under constant change (Koester 2002, 7).

4.1 Identification of biological age

There can be strong variation between the biological and calendar age and the difference in biological age makes a strong difference in sport performance at puberty (Mero 2004, 34). Between the same chronological age groups the difference in biological age might be really strong (Lloyd & all. 2014). Because of this strong difference it is really important to identify the biological age of young athlete (Mero 2004, 32).

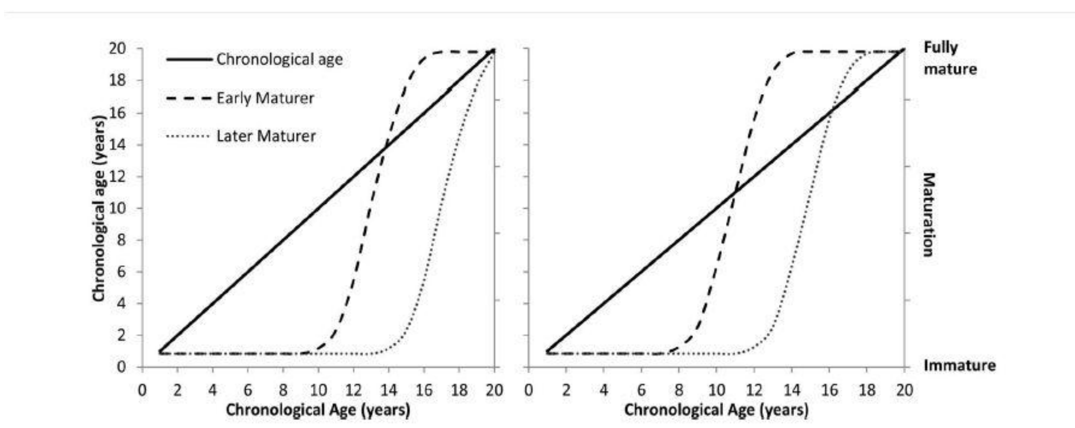

FIGURE 5: Different development trends for early- and late-maturing boys (left) and girls (right). (Lloyd & all 2014)

The different development trends for early- and late-maturing boys and girls are shown in figure 5. (Lloyd & all. 2014). The biological age can differ up to four years in the same training group. Hakkarainen (2009, 74) points out that biological maturation is difficult to determine, while it consists maturation of the secondary sex organs, percentage of predicted height or higher level of hormonal activity.

Tanner (1962, 56-77) introduced four different methods to identify biological age. 1) *Skeletal age*, which is most commonly used and it needs X-ray to record the development stage of bone. Because of radiation this method is used mainly to find out abnormalities (Hakkarainen 2009, 88). 2) Determine the biological age with *dental age* examination, the X-ray is used as in skeletal age. 3) *Morphological age* in size and shape is easy to use but there is a problem in determine the biological age with only size. A child who is taller above average is not necessarily developed in maturity, if he/she is developing as a taller child. Defining the maturity level by the shape of a child has same problems as defining it by size. There might be conflict between the maturity level and shape appearance. This method is not recommended to use as the only method, because strong individual variation may occur (Hakkarainen 2009, 89). 4) *Secondary sex characters* are evaluated by the maturity level of genital, pubic hair and breast development, with scale scale from 1 to 5. Evaluation of secondary sex characters has to be done by medical personnel (Hakkarainen 2009, 89). Figure 6 show Tanner´s standard for genital maturity for boys (Tanner 1966). Every method which is used should take account an individual variation (Malina & all. 2004, 88).

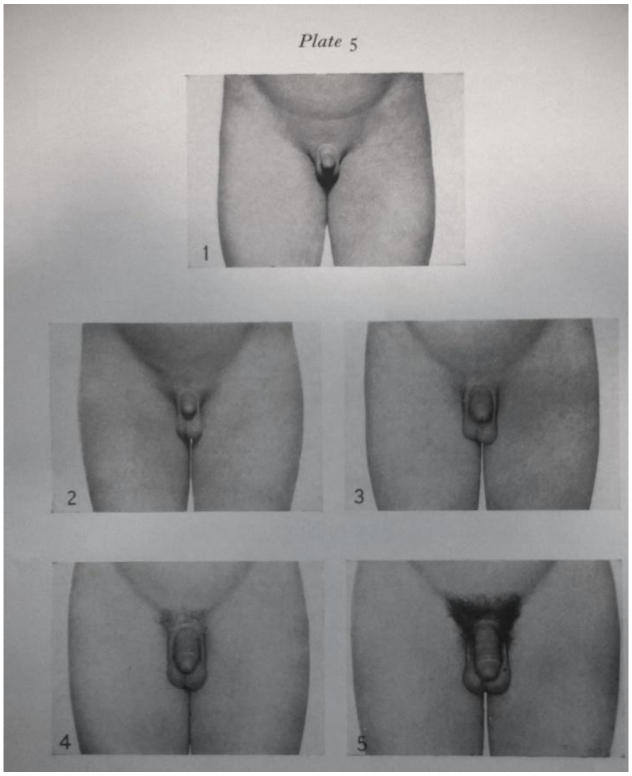

FIGURE 6: Tanner standard for genital maturity for boys. (Tanner 1966, plate 5)

4.1.1 Growth spurt

Children´s height development is really fast after the birth, but the velocity of growth will degrease just before there will be a growth spurt. This adolescent growth spurt will take place in boys between the age from 12,5 to 15 years, but there is individual variations about the age. During this age a person will gain height about 20 cm. (Tanner 1962, 1.) Abbasi (1998) emphasises that the age when growth spurt is taking off is strongly sex-dependent, as the mean take off for growing is for girls 9 years and boys two year later around 11 years of age. There is variability between sources about the age of when growth spurt will begin, as Mero (2004, 11) indicates that growth spurt takes place for Finnish boys at the age of 14 and for girls at the age of 12. Growth of bone ends when the physis closes (Koester 2002, 8). It seems that there is variability between races, and growth spurt and puberty begins earlier than before.

4.1.2 Maturation of the reproductive system

The height spurt is closely related to development of the reproductive system. During this development time penis, testis and pubic hair are developed strongly during puberty for males. (Tanner 1962, 29.) The acceleration of penis takes place around age 13, but there is individual variation between 11 to 14.5 years. Between the ages of 13 to 14 there is enormous variation between boys at the stage of maturity. (Tanner 1962, 29.)

4.2 Physical development during puberty

There are several factors which affect on physical development during puberty. Genetics has main affect on physiological development. Other factors are which time of a year a child has born and social background and these may affect the development for the whole period of growth. (Tanner 1966, 94) During puberty physical growth occurs in gaining more length, mass grow in muscle and overall and bigger skin surface (Hakkarainen 2009, 74). Nutrition has major influence for the time of adolescence (Tanner 1966, 105, Hakkarainen 2009, 86).

A wide range of physiological changes occurs during adolescence. Systolic blood pressure rises, heart rate falls, basal body temperature falls, haemoglobin increases (greater with boys) and some other values changes during adolescent. Hormonal control has major influence on the events of adolescent. (Tanner 1966, 156-176.) Successful young athletes tend to have similar physique than adults in that specific sport (Malina 2004, 83).

4.2.1 Growth

In normal conditions pubertal growth have three different stages; 1.) Acceleration, 2.) Deceleration and 3.) Cessation (Abbassi 1998, 511, Malina & all. 2004, 49). The growth of longitudinal bones occurs near the end of the bone (Koester 2004, 8). The time when growth spurt begins has a large effect on the intensity of growth. When growth begins early it will be more intense. (Tanner 1966, 94) Children who are tall before puberty will began adolescent earlier, hence after puberty there is no difference in height (Abbassi 1998, 511) but there is a difference in weight (Tanner 1966, 95-97). After puberty a person does not gain any height, but weight continuous to increase (Malina & all. 2004, 49).

Age and sex has major influence on peak height velocity. For girls it occurs between Tanner breast stages 2 and 3 and for boys between Tanner testis stage 3 and 4 (Abbassi 1998, 509). Tanner´s (1966) standards for breast maturity and genital maturity for boys are shown on picture 2. The reason for boys to increase more height is because growth phase is longer and growth spurt is stronger during puberty (Mero 2004, 24, Hakkarainen 2009, 78).

Tanner (1966, 134-135) points out that there have not been enough studies made to compare effect of exercise on growth. Tsokalis & all. (2003) point out that exercise has potent influence on hormonal changes, but there is no evidence that it effects on growth and pubertal development. The development of physiological capacity is strongly dependent on growth and maturity, but environment and childhood activity and training affect also strongly on that (Hakkarainen 2009, 75). Several injuries have been reported among the adolescent who participate in sport (Koester 2002, 6). It should be considered, that adolescents are not small adults (Koester 2002, 11) and training should be markedly different (Lloyd & all. 2012). Because maturation has the strongest effect on physical capability, training for pre-puberty children should emphasise improvement of skills (Tsolakis & all. 2003).

4.2.2 Strength development

There is strong development of muscle strength during the adolescent spurt, and this spurt is greater for boys than girls. As a child there is only small sex related differences, but during adolescent there is much larger difference. (Tanner 1966, 201-202, Malina & all. 2004, 219.) Vänttinen & all. (2011) found a significant increase in muscle strength during adolescent, but no difference between subjects who participated in soccer training and their age related counter subject who did not participate in soccer training. Muscle does not have its own centre for growth, but it will grow as a response for a greater demand (Koester 2002, 8). Figure 7 shows the development of strength for boys and girls.

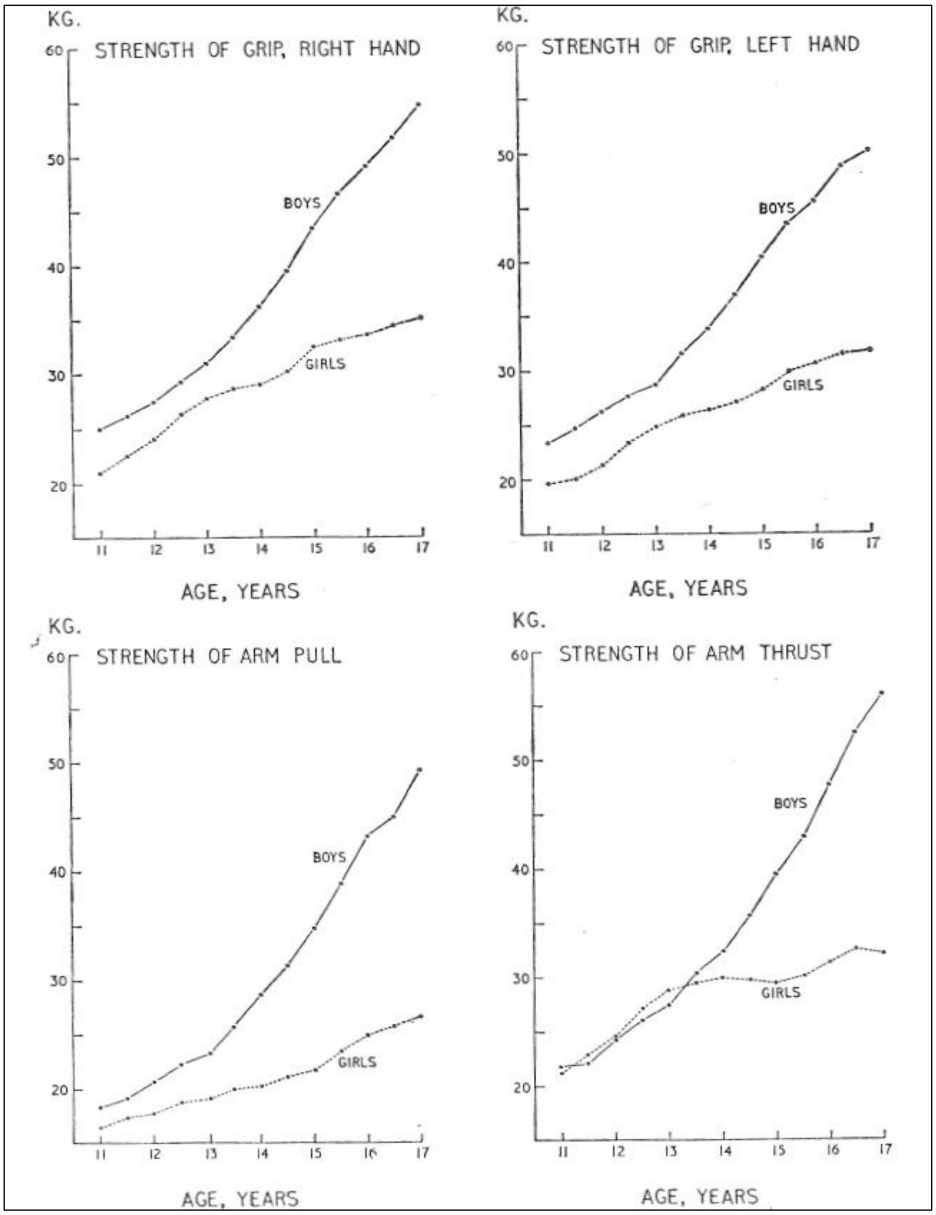

FIGURE 7: Changes in strength level with boys and girls during adolescent (Tanner 1966, 202).

There is a lot of variation in muscle growth during adolescent; it is dependent on the activity level of the muscle and the cross sectional area can increase 5-10 folds. During puberty muscle mass will increase strongly for boys. (Mero & all. 2004, 23, Malina & all. 2004, 154.) The level of strength is increasing linearly for boys until 13 to 14 years when spurt for strength occurs (Malina & all. 2004, 218). Post-pubertal boys have significantly more voluntary isometric force than pre-pubertal boys according to Pääsuke & all. (2001), but force related to body mass is not significantly higher. It is widely agreed that no muscle hyperplasia occurs after birth, even though some studies may indicate otherwise (Mero & all. 2004, 22, Hakkarainen 2009, 91). Increased muscle mass has direct effect on strength.

4.2.3 Motor coordination

Chances in motor coordination during adolescent occur around the age of 13. There is remarkable difference between boys and girls after 13 year of age and boys have main development at the same time as the strength level is increasing (Tanner 1966, 204.). Sex differences are small in fundamental motor tasks during childhood but have small favour for boys. Developments in fundamental skills are linear except in balancing (Malina & all. 2004, 217.).

To perform weaker in a balance task is obvious during adolescent, when changes in body size occur. However, an agile child is not so clumsy during puberty and he is able to perform better in motor coordination tests (Tanner 1966, 204-205.). Because lengths of the limbs are changing during puberty, it effects on motor coordination while lever arms are chancing (Hakkarainen 2009, 82). The findings that the ability to perform in balance and agility tests during adolescent are descending is not reinforced with the cross-sectional data (Malina & all. 2004, 224). Enhancement on motor performance occurs with gaining more age, but it is not known whether there is a spurt in development in skills like running, throwing and jumping (Tanner 1966, 205). Malina & all. (2004, 220-221) suggest that there might be adolescent spurt in jumping, throwing and running.

4.3 Characteristics of pre-puberty in sports

Pre-puberty is the stage where puberty has not yet begun. Biological maturity has a strong effect on a child's performance in sports (Pääsuke & all. 2001). Before puberty the nervous system is developing before visible growth spurt and during this phase it is considered to be preferable phase to develop basic skills needed in ones sport (Hakkarainen 2009, 75; Lloyd & all. 2012). Before the growth spurt dimensions of an individual's limbs are somehow stable and that gives opportunity to learn motor skills easily (Hakkarainen 2009, 77). In youth sports it is really important to understand the individual difference in the time of maturation for each individual and the training background for each individual (Lloyd & all. 2012). Pääsuke & all. (2001) found gender differences between pre-puberty boys and girls in overhand throwing, motor performance and maximal strength. It is important for a coach who is working in child sport to understand the phenomena of maturation in order to develop safe training programs which take to considerations development status of an individual involved (Hakkarainen 2009, 73).

5 PURPOSE OF THE STUDY

The purpose of this study was to examine the suitability of a motor coordination test pattern (KTK) for indicating skating ability in skating speed and agility for pre-puberty children. In addition, possible effects of training background for skating ability and motor coordination, was investigated. The secondary focus was to investigate the effects of biological age on skating ability.

5.1 Research objectives

1. ***The suitability of the KTK-test to indicate skating ability*.** To examine, whether the KTK-test can predict performance in skating tests.

2. ***Effects of training background.*** To examine the effects of training background on the KTK-test and skating test results.

3. ***Effects of biological age on skating agility.*** To examine effects of the biological age on skating agility test performance.

5.2 Hypotheses

Hypothesis 1. The KTK-test can predict skating ability showing a high correlation.

Hypothesis 2. Training background in ice hockey effects on skating results.

Hypothesis 3. Biological age has no significant correlation with the skating agility test, but may have a significant correlation with the 30 m skating test.

6 METHODS

6.1 Subjects

The subjects were 34 boys aged between 9 years 6 months to 12 years 11 months (mean 10 yrs 10 mos ± 6 mos) from two different training groups of Juniori-KalPa ry. 31 subjects managed to complete all the tests included in this study.

6.2 Study design

1. The questioner for each subject about medical status and training background
2. Medical evaluation of the maturity level for each subject.
3. The KTK-test pattern
4. Skating tests

6.3 Maturation level

Every subject was evaluated by a physician on their maturity level according to the Tanner standard for genital maturity for boys. Subjects were advised to meet the physician with their parents or with another adult.

6.4 Body coordination test pattern

For the body coordination test, “Körperkoordinations test für Kinder” (KTK-test) was applied. The KTK-test was performed before the training group had their normal ice practice. Before the test subjects were instructed to warm-up with light jogging for 15 minutes. The KTK-test pattern includes four different subtests and each test result is converted according to the age related scale. The total summation of each test gives the overall KTK MQ result (Kiphard & Schilling, 2007). These four tests were:

1. **Balancing Backward:**

   In this test subject is walking backward 3 times on each 3 different bar. Every bar is 3 meter long but the width of the bar varies. The first one is 6 cm, the second 4.5 cm and the third 3 cm wide. In this test every step which is made is counted (figure 8). The maximum amount of steps for each attempt is 8. The result from this test is the summation of steps made at all nine attempts giving the maximal result of 72 steps. The total amount of points is counted and then converted to the MQ result. Before the test, subjects had one practice walk forward and backward on every bar. (Kiphard 1979,48-51).

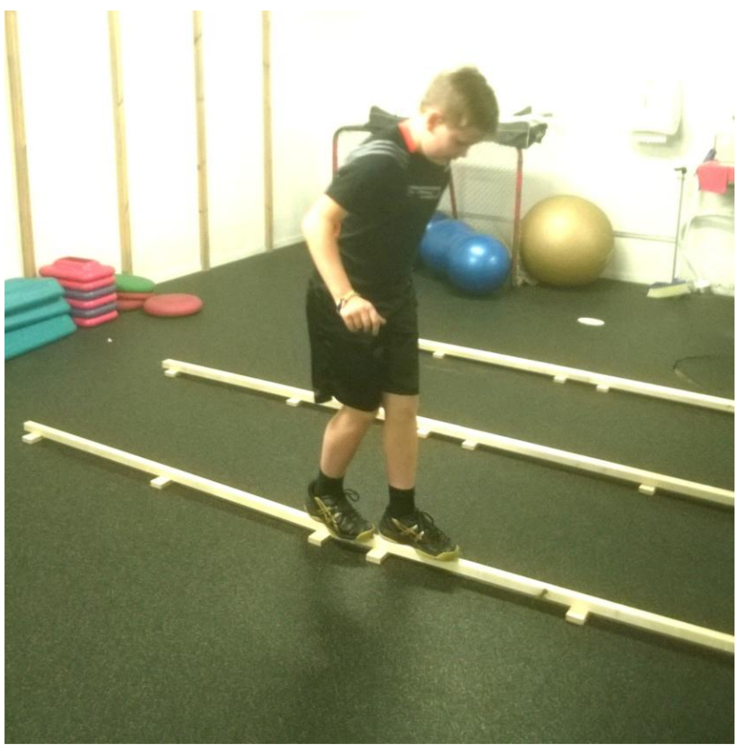

FIGURE 8. Subject balancing backwards on a 3 cm wide and 3 m long bar.

2. One leg jumping:

This test is performed unilaterally and both legs are evaluated for the results. A subject has to take speed with hopping on one leg and then jump over the increasing pile of soft pillows. Jumping height is varied from 0 cm to 60 cm. The performance is approved when a subject is able to take two hops with one leg after jumping over the pile. Every attempt is evaluated and subject has three attempts on every height. Getting over the pile on the first attempt gives 3 points, getting over with the second attempt gives 2 points and with the third attempt subject will get 1 point. Total amount of points for both legs are counted and then converted to the MQ result. Before the test, subjects had one practice performance over a 5 cm obstacle. The starting height for the test was 25 cm. (Kiphard 1979,48-51).

3. Sideway jumping:

This test is performed bilaterally. This test is limited by time and a subject has 15 seconds to jump over a 2 cm high and 4 cm wide wooden rod. All accepted jumps are counted to the result. A subject has two attempts and both results are counted and then converted to the MQ result. Before the test subjects had five practice jumps. (Kiphard 1979,48-51).

4. Moving sideways:

In this test a subject is moving one plate on sideways and he is standing on the other plate. A subject has 20 second to perform and every movement of the plate is one point and step on to the other plate is one point. The points are the result from this test. The plate has to be moved with two hands. A subject had two attempts and performed the movement for both ways. The total amount of points for these two attempts is counted and then converted to the MQ result. Before the test subjects had training for five sideway movements. (Kiphard 1979,48-51).

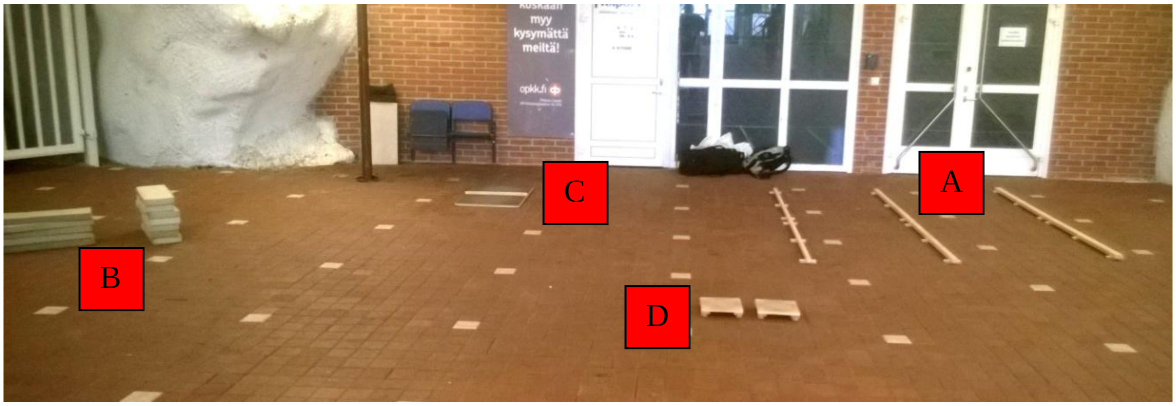

FIGURE 9. Equipment for the KTK-test: a) bars for balancing backwards, b) obstacles for one leg hopping, c) plate for jumping sideways and d) two plates for moving sideways.

Installation of the equipment for the KTK-test is illustrated in figure 9.

After calculating all results and when they are converted to MQ results, the overall MQ result is converted accordingly (Kiphard & Schilling, 2007). The MQ total result is then categorized into five groups as shown in table 2.

TABLE 2. Classification of motor coordination in KTK test. (Modified from Kiphard & Schilling, 2007)

MQ result	Classification	Group	Percentage Share
131-145	High	5	2
116-130	Good	4	14
86-115	Normal	3	68
71-85	Conspicuous	2	14
56-70	Disturbed	1	2

6.5 Skating tests

The skating performance was tested with two different tests: a 30 m skating test, with 10 m split time and a skating agility test. In both test subjects had 3 attempts and the best result was counted. There was a 2 min rest period between the attempts. The time was measured with the Digitest-1000 digital timer which was connected to the reflecting photocells. The photocells were mounted 90 cm above ice surface to avoid disturbance of the ice hockey stick. Both tests were performed on the same day. The 30 m skating test was done first and after that the skating agility test. Subjects performed warm-up individually according to guidance which was provided. The warm-up protocol included movements which all subjects were familiarized at their own training groups. Subjects came to the skating tests in groups of four subjects, in order to get enough recovery and avoid too long waiting. All skating tests were performed with the full ice hockey equipment.

To ensure the valid test all photocells, reflecting mirror and cone positions for the tests were measured and marked on ice. A hole to the ice was drilled according to the measurements and then filled with beetroot juice.

6.5.1 30 m skating test

The 30 meter skating test was performed and 10 m split time was collected. The starting point of a subject was marked 30 cm before the starting line. The start for the test was at subjects own will, after he was given the authorization to perform (IIHCE, 2014). The photocells were 2 m apart from reflecting mirrors.

6.5.2 Skating agility test

The skating agility test consists of several different skating techniques used in ice hockey. The skating performance in ice hockey requires forward and backward skating, different turning techniques and the ability to stop. (IIHCE, 2014)

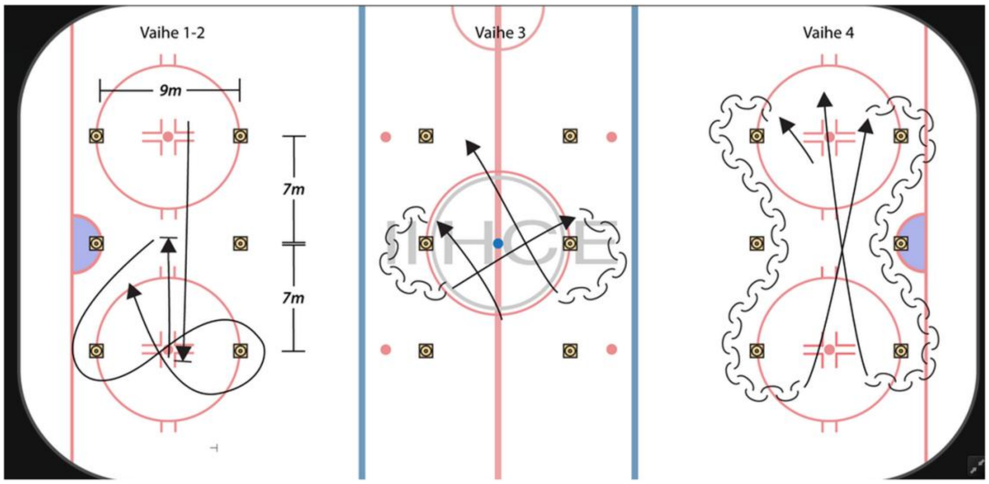

FIGURE 10. Skating agility test performance instructions. (IIHC, 2014)

The instructions for the skating agility test includes three stages: 1) forward skating and stop at the far end of the test area, skating forward back to the middle point of the test area and perform the stop facing at the same direction as in the first stop, then performing two skate quick turns over the far end pylons for both directions, 2) perform a winger turn over both pylons in the middle of the area, 3) perform a defender turn and then skating backwards and zigzag over pylons on one side, at the far end perform an U-turn and skate forward to the other side of the and then perform the same protocol on the other side, then skating to the finish (Figure 10.).

6.6 Statistical analyses

For statistical analysing of the results SPSS, version 19 (SPSS Inc., Chicago IL.) and Microsoft Office Excel 2007 (Microsoft Inc., USA) were used.

For all results, values for mean (M), standard deviation (SD), minimum (min), maximum (max) and number of subjects (N) were analysed. Correlations were analysed with SPSS using bivariate two tailed Pearson's correlation with significance level of $p \leq 0.05$. For the group analyses one-way ANOAVA was used with the significance level of $p \leq 0.05$. Tukey post-hoc analyse was performed in the group analyses.

7 RESULTS

7.1 Descriptive statistics

Subjects in this study were 31 boys from two different U-11 training groups of Juniori-KalPa. The mean values of subjects' age, training background and maturity level are illustrated in table 3.

TABLE 3. Subjects' age, training background (TBG) and maturity level mean and standard deviation.

	Mean	SD	N
age (y)	10.85	0.49	31
Training background (y)	4.7	0.93	31
Maturity Level	1.55	0.68	31

In the KTK subtest the highest results was collected on jumping sideways (MQ (JS) M= 124.7, SD= 10.8) and lowest results was collected on balancing backward (MQ (BB) M= 96.4, SD= 11.7) (Table 4.).

TABLE 4. Results in the KTK test total, (tot), balancing backwards (BB), one leg hopping (OLH), Jumping sideways (JS) and moving sideways (MS).

	Mean	Minimum	Maximum	SD	N
KTK, MQ (tot)	107.9	91	134	11.0	31
MQ (BB)	96.4	77	121	11.7	31
MQ (OLH)	105.5	85	120	10.6	31
MQ (JS)	124.7	99	145	10.8	31
MQ (MS)	98.4	74	133	14.3	31

From all 31 subjects 77.4 % (N=24) is in the group 3, 19.4 % (N=6) in the group 4 and 3.2 % (N=1) in the group 5 (SD= 0.51). (Table 5.).

TABLE 5. Distribution and percentage of the KTK-groups from 1 to 5.

Group	Frequency	Valid Percent	Cumulative Percent
3	24	77.4	77.4
4	6	19.4	96.8
5	1	3.2	100
Total	31	100	100

The subjects performed in 10 m split time in 2.15 s (SD= 0.099). The mean value for 30 m skating test was 5.20 s (SD =0.18) In SAT subjects had a mean value of 41.76 s (SD= 2.18). (Table 6.)

TABLE 6. Results in the 30 meter skating tests and the skating agility test (SAT) (max, min, mean and standard deviation).

	Mean	Minimum	Maximum	SD	N
10 m split time (s)	2.15	1.98	2.36	0.10	31
30 m skating test (s)	5.20	4.83	5.58	0.18	31
Skating agility test (s)	41.76	38.26	47.04	2.18	31

From all 31 subjects 35.5 % (N=11) was in group 1, 35.5 % (N=11) is in group 2 and 29.0 % (N=9) in group 3 (SD= 0.81) (Table 7.).

TABLE 7. Distribution and percentage of the skating agility test (SAT) groups from 1 to 3.

Group	Frequency	Valid Percent	Cumulative Percent
1	11	35.5	35.5
2	11	35.5	71.0
3	9	29.0	100
Total	31	100	100

7.2 Correlations

The KTK MQ (tot) correlated significantly with the skating agility test r = -0.527 ($p \leq 0.01$), but no statistical significant correlation between the 30 m skating test. The skating agility test correlated significantly ($p \leq 0.01$) with the 30 m skating test (r = 0.555) (Table 8.).

TABLE 8. Correlations between the KTK MQ (tot), the skating agility test (SAT) and the 30 m skating test (30 m ST).

	KTK MQ (tot) vs. SAT (s)	KTK MQ (tot) vs. 30 m ST (s)	SAT (s) vs. 30 m ST (s)
Pearson Correlation	-0.527**	-0.329	0.555***
N	31	31	31

** Correlation coefficience is significant at the level of 0.01 (2-tailed),

*** Correlation coefficience is significant at the level of 0.001 (2-tailed)

Figure 11 illustrates the correlation between the KTK MQ (tot) and the skating agility test (SAT).

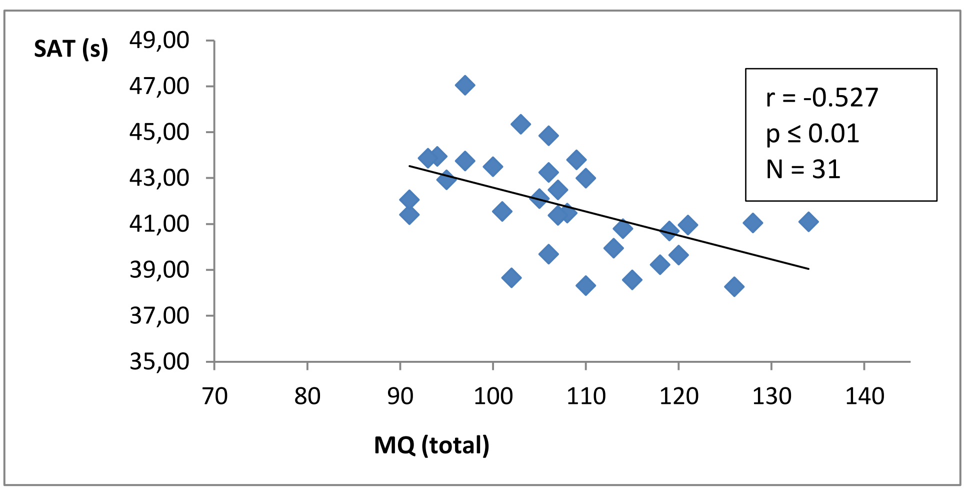

FIGURE 11. Relationship between KTK MQ (tot) and SAT.

The skating agility test correlated significantly (p ≤ 0.01) between MQ (OLH) (r = -0.660) and MQ (JS) (r = -0.507) and (p ≤ 0.05) between MQ (MS) (r = -0.452). MQ (BB) showed no statistically significant correlation between the skating agility test (figures 12, 13, 14 and 15).

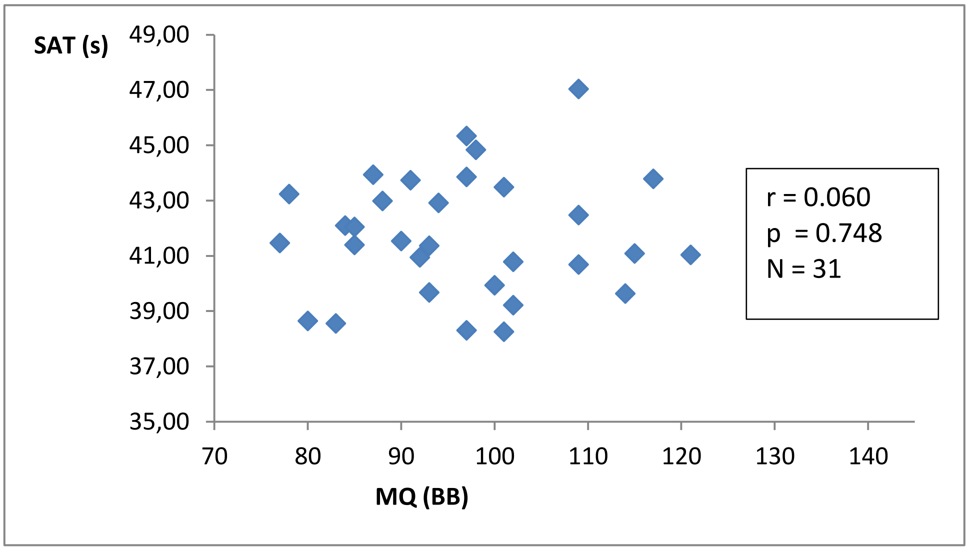

FIGURE 12. Relationship between SAT and MQ (BB)

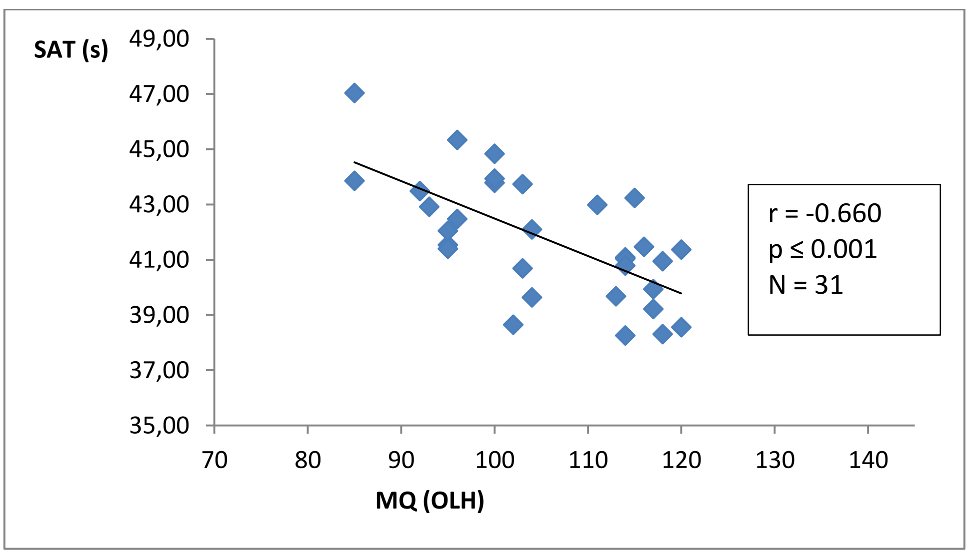

FIGURE 13. Relationship between SAT and MQ (OLH)

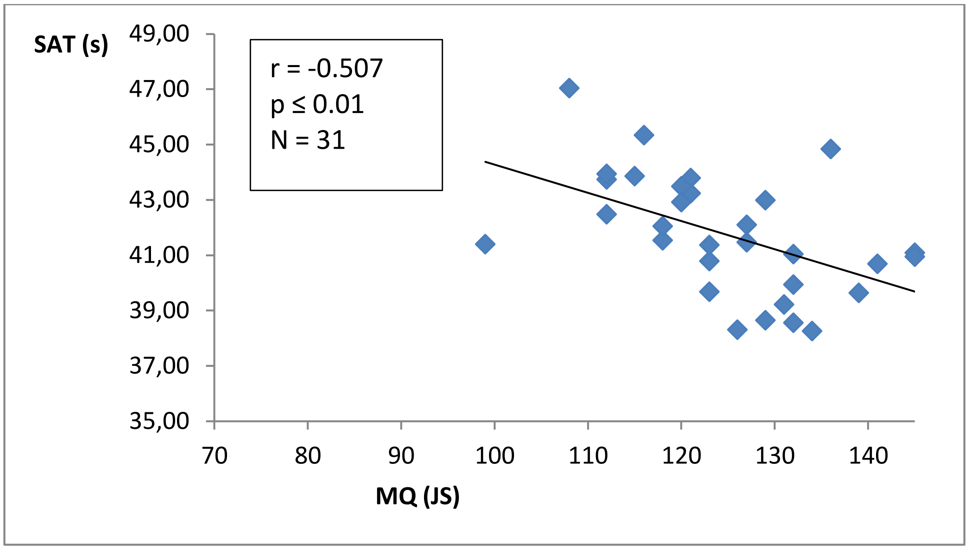

FIGURE 14. Relationship between SAT and MQ (JS)

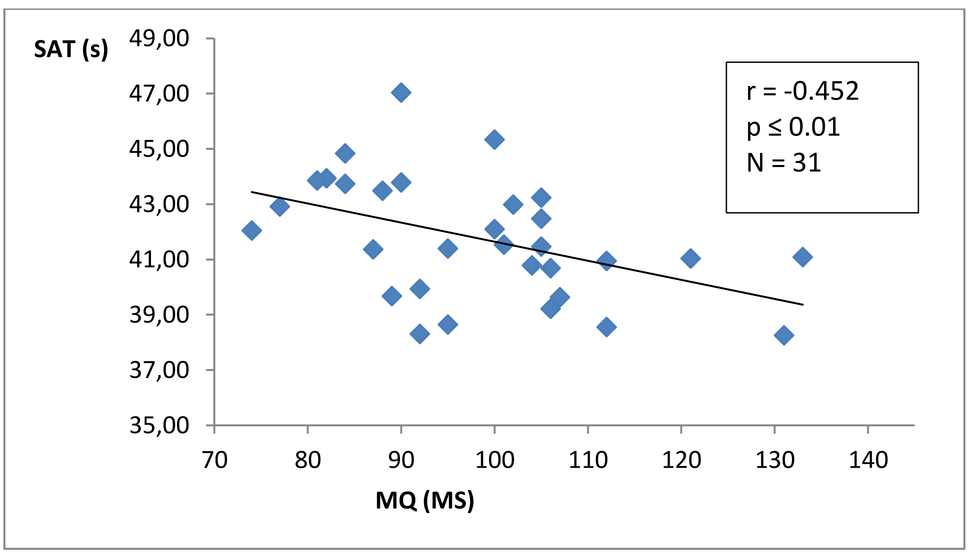

FIGURE 15. Relationship between SAT and MQ (MS)

Calendar age did not correlate with background or the KTK MQ (tot) test. Training background showed a significant correlation ($r = 0.39$, $p \leq 0.05$) with the KTK MQ(tot) test (Table 9).

TABLE 9. Correlation between age, training background (TBG) and KTK MQ (tot).

	Age (y) vs. Training Background (y)	Age (y) vs. KTK MQ (tot)	Training Background (y) vs. KTK MQ (tot)
Pearson Correlation	0.35	0.25	0.39*
N	31	31	31

* Correlation coefficience is significant at the 0.05 level (2-tailed)

Training background did not correlate between the skating agility test or with the 30 m skating test. Calendar age did not correlate with skating agility test or with 30 m skating test. Skating agility test indicated statistically significant correlation ($p \leq 0.01$) with 30 m skating test ($r = 0.56$). There was a significant correlation ($r= 0.92$, $p<0.01$) between the 30 m skating test and 10 m split time.

7.3 Group analyses

7.3.1 KTK Groups analyses

The subjects were divided into three groups according their performance in KTK MQ (tot). Because only one subject reached to level 5 in KTK groups, groups 5 and 4 were merged in this analysis. No subjects were in group 2 or 1 and group 3 was divided in half in this analysis. In this analysis KTK group 4 consisted KTK MQ (tot) results from 134 to 116, group 3 consists results from 115 to 110 and group 2 consists results from 109 to 91.

TABLE 10. Descriptive statistics for KTK grouped in 3 groups for analyses on skating agility (SAT) results.

Group	N	Minimum	Maximum
2	7	41.40	47.04
3	11	38.31	45.34
4	7	38.26	41.09
Total	31	38.26	47.04

The Levene test of homogeneity revealed variance between groups' homogeneity in skating agility test ($p \leq 0.228$). There were statistically significant difference between the group means as determined by one-way ANOVA ($F(2,28)=5.74$, $p<0.01$).

TABLE 11. Multiple comparisons for KTK grouped in 3 groups on skating agility (SAT).

(I) KTK G1-5	(J) KTK G 1-5	Mean Difference (I-J)	Standard Error	Significance
2	3	1.88	0.854	0.088
2	4	3.44**	1.017	0.006
3	4	1.55	0.854	0.182

** Difference is significant at the 0.01 level

A Tukey post-hoc test revealed a statistically significant difference (3.44±1.017 s., $p \leq 0.01$) between KTK group 4 and group 2. There were no statistical significant difference between group 3 and group 4 or between group 3 and group 2 (Table 11.). Comparison for SAT mean values between KTK groups is illustrated in figure 16.

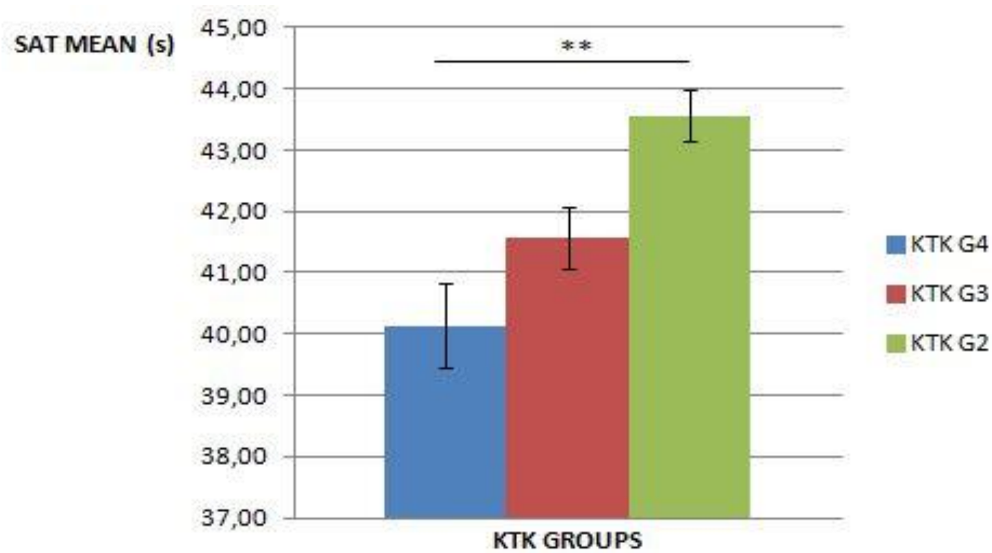

FIGURE 16. Mean values for KTK groups on skating agility (SAT) test.

KTK group 2 had a mean value of 5.29±0.15 s (N=7), group 3 had mean value of 5.19±0.19 s (N=17) and group 4 had mean value of 5.15±0.15 s (N=7) in 30 meter skating test.

The Levene test of homogeneity revealed variance between groups' homogeneity in 30 meter skating test ($p \leq 0.450$). There were no statistically significant difference between the group means as determined by one-way ANOVA ($F(2,28)=1.31$, $p<0.287$).

7.3.2 SAT Group analyses

Subjects were divided into three groups according to their performance in the skating agility test. SAT group 1 consisted results which were < 40.99 s, group 2 from 41.00 s to 42.99 s and group 3 > 43.00 s.

TABLE 12. Descriptive statistics for skating agility groups (SAT G1-3) on overall KTK result (KTK MQ (tot), balancing backwards (MQ (BB), one leg hopping (MQ (OLH), jumping sideways (MQ (JS) and moving sideways (MQ (MS).

Test	Group	N	Mean	SD	Min.	Max.
KTK MQ (tot.)	1	11	114.9	6.98	102	126
	2	11	107.0	13.70	91	134
	3	9	100.6	5.73	93	109
	Total	31	107.9	11.05	91	134
MQ (BB)	1	11	97.6	10.15	80	114
	2	11	94.6	14.12	77	121
	3	9	97.2	11.50	78	117
	Total	31	96.4	11.74	77	121
MQ (OLH)	1	11	112.7	6.59	102	120
	2	11	104.8	10.34	93	120
	3	9	97.3	9.35	85	115
	Total	31	105.5	10.62	85	120
MQ (JS)	1	11	132.3	7.14	123	145
	2	11	122.7	11.78	99	145
	3	9	117.9	8.15	108	136
	Total	31	124.7	10.83	99	145
MQ (MS)	1	11	104.2	12.12	89	131
	2	11	100.0	17.27	74	133
	3	9	89.3	8.23	81	105
	Total	31	98.4	14.29	74	133

The Levene test of homogeneity revealed variance between groups' homogeneity in KTK MQ(tot) ($p \leq 0.204$), MQ(BB) ($p \leq 0.505$), MQ(OLH) ($p \leq 0.114$), MQ(JS) ($p \leq 0.453$) and MQ(MS) ($p \leq 0.320$).

TABLE 13. Results in ANOVA for skating agility test groups (SAT (G1-3) in overall KTK result (KTK MQ (tot), balancing backwards (MQ (BB), one leg hopping (MQ (OLH), jumping sideways (MQ (JS) and moving sideways (MQ (MS).

		df	F	Sig.
KTK MQ (tot)	Between Groups	2	5.52	0.010
	Within Groups	28		
	Total	30		
MQ (BB)	Between Groups	2	0.19	0.830
	Within Groups	28		
	Total	30		
MQ (OLH)	Between Groups	2	7.50	0.002
	Within Groups	28		
	Total	30		
MQ (JS)	Between Groups	2	6.29	0.006
	Within Groups	28		
	Total	30		
MQ (MS)	Between Groups	2	3.18	0.057
	Within Groups	28		
	Total	30		

There were statistically significant differences between group means as determined by one-way ANOVA in KTK MQ(tot) ($F(2,28)=5.52$, $p \leq 0.010$), MQ(OLH) ($F(2,28)=7.50$, $p<0.01$) and MQ(JS) ($F(2,28)=6.29$, $p<0.01$). (Table 13).

A Tukey post-hoc test revealed a statistically significant difference (14.35) between SAT group 1 (114.91 ± 6.98, $p \leq 0.01$) and group 3 (100.56 ± 5.73) in KTK MQ(tot) results. A significant difference (15.39) was observed between SAT group 1 (112.73 ± 6.59, $p \leq 0.01$)

and group 3 (97.33±9.35) in MQ(OLH) results, between SAT group 1 (132.27±7.14, p≤0.01) and group 3 (117.89±8.15) in MQ(JS) results and between SAT group 1 (104.18±12.12, p≤0.050) and group 3 (89.33±8.23) in MQ(MS) results. (Table 13).

TABLE 14. Multiple comparison for skating agility groups (SAT G1-3) on overall KTK result (KTK MQ (tot), balancing backwards (MQ (BB), one leg hopping (MQ (OLH), jumping sideways (MQ (JS) and moving sideways (MQ (MS).

Dependent Variable	(I) SAT G 1-3	(J) SAT G1-3	Mean Difference (I-J)	Std. Error	Sig.
KTK MQ (tot)	1	2	7.9	4.13	0.153
	1	3	14.4**	4.35	0.007
	2	3	6.4	4.35	0.315
MQ (BB)	1	2	2.9	5.15	0.840
	1	3	0.3	5.43	0.998
	2	3	-2.6	5.43	0.883
MQ (OLH)	1	2	7.9	3.78	0.110
	1	3	15.4**	3.99	0.002
	2	3	7.5	3.99	0.164
MQ (JS)	1	2	9.6	3.97	0.058
	1	3	14.4**	4.19	0.005
	2	3	4.8	4.19	0.489
MQ (MS)	1	2	4.2	5.69	0.745
	1	3	14.9*	6.00	0.050
	2	3	10.7	6.00	0.196

* Difference is significant at the 0.05 level, ** Difference is significant at the 0.01 level

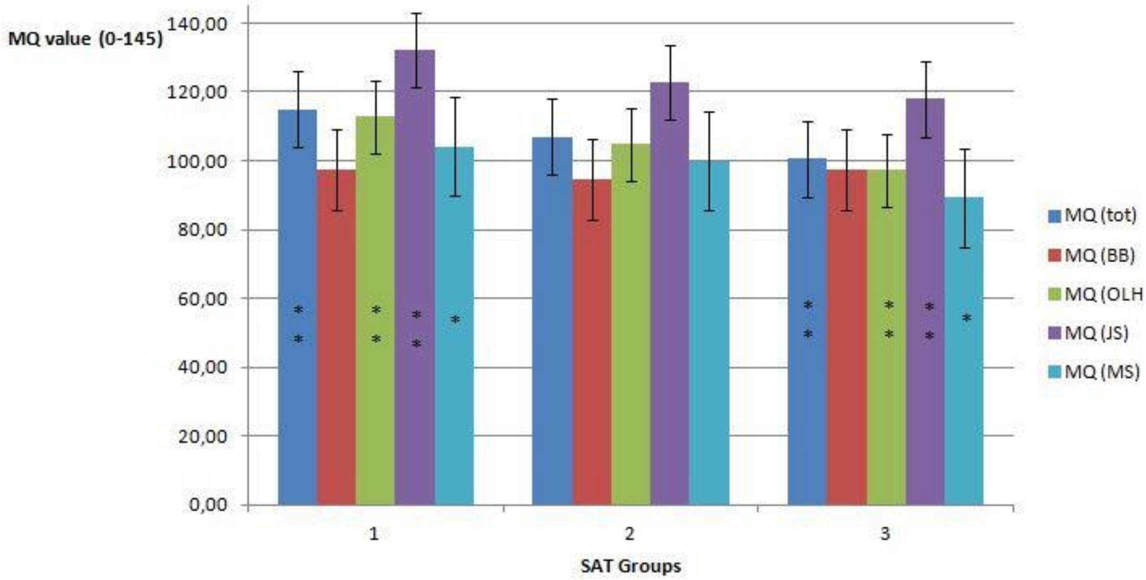

FIGURE 17. Mean values for skating agility (SAT) groups on overall KTK result (KTK MQ (tot), balancing backwards (MQ (BB), one leg hopping (MQ (OLH), jumping sideways (MQ (JS) and moving sideways (MQ (MS). (** = p< 0.01, * = p≤ 0.05 between groups)

The differences between SAT groups in KTK MQ(tot), MQ(BB), MQ(OLH), MQ(JS) and MQ(MS) are illustratet in figure 17.

8 DISCUSSION

The present study showed in the group analyses that players who performed well, reaching over 116 points in MQ(tot) in the KTK- test, performed also statistically better in the skating agility test than players who reached less than 110 points (3.44±1.02 s., $p \leq 0.01$). The analyses for the skating agility test indicated the significant ($p \leq 0.01$) difference between group 1 and 3 in KTK MQ(tot.) (14.4±4.35), MQ(OLH) (15.4±3.99) and MQ(JS) (14.4±4.19) and a statistically significant difference ($p \leq 0.05$) in MQ(MS) (14.9±6.00). There were no statistical differences between the groups in MQ(BB). This finding also emphasises that players who performed in the skating agility test at the high level had better motor coordination, respectively.

The distribution of the subjects in the KTK groups was more upward than what Kiphard & Shilling (2007) showed (table 2) 77 % versus 68 % in group 3, 19 % versus 14 % in group 4 and 3 % versus 2 % in group 5. There were no subjects in groups 1 or 2 in this study, which indicates that none of the subjects had problems in motor coordination (Kiphard, 1979, 52). There was no significant difference between the groups in 30 m skating test, which strengthens the validity of the SAT test in this study.

In this study the KTK test showed skating ability with the high statistical significance ($r = -0.527$, $p \leq 0.01$) in the skating agility test, but not in the 30 m skating test. On the other hand, 3 out of the 4 KTK tests indicated statistical a significant correlation between skating agility test. One leg hopping had the strongest indication for skating agility ($r = -0.660$, $p \leq 0.01$) and jumping sideways has also a significant correlation ($r = -0.507$, $p \leq 0.01$) between SAT. There was a highly significant correlation ($r = 0.916$, $p < 0.01$) between 10 m and 30 m skating test results, which was predictable before the study. The skating agility test also indicated a significant (($r = 0.555$, $p \leq 0.01$) correlation with 30 m skating test.

Motor coordination is an important factor for skating agility and this is why the KTK-test is the useful test for pre-puberty ice hockey players to evaluate their possible performance capacity on ice. These results support the first hypothesis of the present study. One leg hopping results are in alignment with the previous study of Villemejane (2009), which indicated that unilateral power production of lower limbs had a significant correlation with skating performance. There was no significant correlation between balancing backwards and the skating agility test. This finding is not in an alignment with findings of Behm & all. (2005) who found a significant correlation between balance and skating with under 19-year old players.

Training background or calendar age had no statistically significant correlation between skating performances, but training background did ($r = 0.387$, $p \leq 0.05$) with the KTK MQ(tot) test. These findings do not support the second hypothesis of this study. This result may indicate that ice hockey training can develop motor skills for young players. The maturity level had no statistical significant factor in any off-ice or on-ice performance results. The main reason for this may be the small variance between subjects (1-3), which indicates that all subjects were at the pre-puberty stage (Tanner 1962, 29.).

The results of this study give a strong background for using the KTK-test in ice hockey for a motor coordination test, which has effect on skating performance in ice hockey. This study is the first one to study the suitability of skating agility test for pre-puberty children. The significant correlation between the skating speed test and skating agility test ($r = 0.555$, $p \leq 0.01$) could be interpreted as violation of relevance. However, the group analyses indicate the importance of the skating agility test.

Skating tests were also unfamiliar to subjects, but practise for all tests was provided prior to the actual test. In the skating test the ice surface is getting worse after several attempts, which may influence to the results. This influence was controlled by chancing the skating place after 12 players. Warm-up before the tests was not monitored, but it should not effect on the KTK results, but may have some effect on skating results. However, having three attempts should diminish effects of not properly warmed-up. The tests were located at the end of the season, which may have some minor influence of making full attempt in the test, even though the subjects were volunteered and performed with their best effort in all tests.

The results of this present study indicate that ice hockey training can enhance motor coordination and coaches should include off-ice trainings in their training programmes which enhance motor coordination. For pre-puberty children training should include wide range of different stimulus for the nervous system, muscle strength and aerobic endurance. Ice hockey skating is unilateral work that the present study indicates the importance of the ability to perform unilaterally also off-ice. Motor coordination is really an important factor for ice hockey performance and it should be taken seriously into considerations when planning short and long term plans for children's training. In studies made earlier in gymnastics, subjects who reached over 120 points were performing better after two years in elite competitions (Vandorpe & all. 2012b). This finding brings up a follow up for this study to investigate, if there would be a same kind of pattern also in ice hockey.

There are however, some limitations and weak points in the present study. All the subjects were from the same club, even though they came from two different training groups. There is no real data collection for the training background and results from that perspective are questionable. The KTK-test protocol was unfamiliar to all subjects, but the KTK-test has been proved to be a valid test (Vandorpe & all. 2011). The deviation of the KTK MQ(tot) result in groups is not really suitable for children participating in sport, because most of the subjects will fit in group 3 however, it may be a useful test for talent identification. In the present study no anthropometric analyses were performed.

The KTK-test is useable and it should be included to the Finnish Ice Hockey Associations' talent screening program called Leijonatie and for all junior ice hockey clubs' test protocol prior puberty. With this test protocol weaknesses in motor coordination can been screened and suitable actions can be taken accordingly. Motor coordination has also a connection to intellectual competence, which is needed in the fast game of ice hockey. Vänttinen (2013, 78) pointed out that cognitive skills are better for soccer players who are at higher level in expertise, especially for older players. As the KTK-test is originally designed to point out problems in motor coordination, which are connected to problems in cognitive learning (Kiphard 1979, 50), it strengthens the conclusion that the KTK is a valid test for players in ball games.

Training programmes for pre-puberty children should include a wide range of different stimulus with included training for motor coordination and unilateral work. Ice hockey training may have positive effects on motor coordination, but it should not be taken as an only training method for motor coordination.

Future interests from present study may arise are: 1) are the findings of this study controversial over Finland and worldwide, 2) can the KTK-test predict future performance also in ice hockey and 3) what is the importance of the skating agility test in future performance.

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