ABSTRACT

The research investigates the relationship between fundamental motor skills and sport specific skills for ten year old boys and girls within the context of hockey. Gender differences in baseline fundamental motor skills are explored and compared to the effects of instruction. The effect of instruction on either fundamental motor skills and hockey sport specific skill are determined by repeating the initial motor performance test which combines fundamental and sports specific skill items. The performances of seventy five children aged ten years are investigated through both process and product measures. The data was analysed using a repeated MANOVA which detects the levels of significance in the changes in skill level after intervention. Significant differences were detected in the pretest hockey hit and the two handed side arm strike, however, there were no significant differences on skill levels as a result of three diverse treatments. Comparisons are made between males and females in their initial skill levels and their relative changes in performance.

Introduction

Fundamental motor skills form the foundation for participation in sports (Gallahue 1989; Aicinena 1992). There is acceptance of a relationship between fundamental motor skills such as: locomotion; non locomotion; and manipulative skills forming the foundation for sport specific skills (Gallahue 1989; Holland 1986; Rose & Heath 1990;
Walkley, Holland, Treloar & Probyn-Smith (1993). The Victorian Department of Education (1996) states the relationship is “most skills used in sports and movement activities are advanced versions of fundamental motor skills.” (p.4). Furthermore, Haubenstricker & Seefeldt (1986) indicates there is a ‘proficiency barrier’ between the acquisition of fundamental skills and the successful transition to sport specific skills. This is modelled in the pyramid of skills based on Gallahue’s motor development theory. The formative years of motor development indicate children build upon a foundation of physical skills in the play and learning environments (Gabbard, 1992). The examination of children’s level of proficiency in fundamental motor skills and the proposed link to sport specific skills is an important exploration. Espenschade and Ekert (1980) note that it is not enough to assume movement control and skill development will automatically occur for all children as a consequence of having experience in movement. The learning environment must make it possible.

Recent related research within Australia utilising qualitative measures of a range of motor skills report a poor level of motor skill performance of Australia’s youth (Thompson, McCormack, Thomas & Woodcock, 1995; Walkley, Holland, Treloar & Probyn-Smith 1993). These findings mirror previous studies within the United State (Holland 1986; Kelly, Reushelein & Haubenstricker 1989; Ulrich & Ulrich, 1985). Research from both countries report marked gender differences in the performance of motor skills (Kelly et al.; Thompson et al. 1995; Walkley et al. 1993). Differences in the performance of motor skills have been attributed to biological factors (Clark & Phillips 1987; Smoll & Schultz 1990), environmental and sociological factors (Greendorfer & Brundage 1987; Krombolz 1997; Thomas & French 1985; Williams 1983). However, some researchers indicate it is a combination of both biological and environmental factors. Additionally, an emerging challenge to the tools employed in measuring motor skills and the subsequent interpretation of results (Hands & Larkin 1997; Smoll & Shultz 1990) is widening this debate. Regardless of the explanations of varying motor skill performance based on gender, there is a need to investigate the relationship between fundamental motor skills, sport specific skills, and the differentiation for both boys and girls.

The aim of this study is to investigate the interrelationship between fundamental motor skills and sport specific skills, and consider levels of performance for both genders. As there is a broad range of skills within the two categories of skills (fundamental and sport specific), a pragmatic choice to choose one skill related to both categories has resulted in the two handed side arm strike and the hockey hit being selected for this investigation. Due to the consistent evidence of males outperforming females on a range of motor skills, it was important to select skills with minimal bias against girls. Paralleling this consideration is the selection of a specific skill from a sport with minimal gender bias. Hockey encourages equal participation of both girls and boys and was therefore selected with these considerations as a guide. In addition to investigating the performance of two related skills (the two handed side arm strike and the hockey hit), the selection of the motor skill, and the sport needed to be such as to provide the best opportunity for equal performance for both boys and girls.

METHOD

Research Design

A pretest and posttest comparison on treatment research design was employed. The sample was randomly allocated to three matched groups on the basis of the two hand sidearm strike and the hockey hit pretest scores. A one way ANOVA was employed to ensure there were no significant differences between the groups. The matched groups allowed for changes in the dependent variables of the two handed side arm strike and the hockey hit to be
attributable to the interaction of the effect of the independent variables, namely treatment (three) and gender (two). The treatment consisted of four weeks of three different types of instruction. Group one received instruction on a range of fundamental motor skills and a concluding minkey game; group two received instruction on Minkey (modified hockey) skills and a concluding minkey game; and group three played the game of Minkey for the entire skill development phase of intervention with no overt instruction allowed.

Subjects

Seventy five ten year old children were included in this study on the basis of parental permission. The sample (n=76) included 32 males and 44 females.

Procedures

Students were initially tested (pretest) on the two hand sidearm strike. They were given up to five trials to feel comfortable with the testing equipment and environment. They were then asked to hit for distance and accuracy on three trials which were video taped to facilitate qualitative process analysis. Product measures of distance and accuracy were recorded but will not be presented in this paper.

Following the pretest, assignment of matched groups to four weeks of intervention of three types, was followed by the posttest. The procedures for the posttest were identical in design and implementation as the pretest. Overall, each candidate had five strikes at the ball. The first two strikes were practice strikes and strikes three, four and five were video recorded for process score analysis at a later time.

Two Handed Side Arm Strike

The protocols were adopted from the Victorian Department of Education Fundamental Motor skill manual due to its reliability rating (.91), validity and the cultural commonality.

Protocols for the Two Handed Side-Arm Strike include:

1. The candidate stands within the striking area and adjusts the top of the tee to the height of the subject’s waist;
2. The candidate grips a bat and strikes two practice balls into the target area;
3. The candidate is instructed to strike the ball as accurately as possible along a marked line between two columns of witches hats. This procedure is then repeated for a second and third attempt; and,
4. The candidate is then instructed to strike the ball as hard as possible and as straight as possible along a marked line between two columns of witches hats.

Hockey Hit Test

Due to the absence of a validated instrument to measure hockey skills, an instrument was adapted from the Australian Sports Commission’s ‘Aussie Sport’ Minkey Hockey Profile. In order to boost the validity of the instrument it was sent to the Head Hockey Coach at the Australian Institute Of Sport and the Director of Coaching and Development in Western Australia. Minor modifications were made on the advice of these two experts and the
instrument was employed in this study. The protocols and analysis criteria for the two handed hockey hit are:

Protocols for the Hockey Hit include:

1. The candidate stands within the hitting area facing target area, hockey stick in hand;
2. The candidate hits two practice balls into the target area;
3. The candidate is instructed to hit the ball as accurately as possible along a painted white line between two columns of witches hats. This procedure is then repeated for a second attempt; and,
4. The candidate is then instructed to hit the ball as accurately and as hard as possible at the same time along the white painted line between two columns of witches hats.

ANALYSIS

Analysis of the product and process scores are detailed below. Following the pretest, matched groups were randomly allocated to groups. A one way ANOVA detected no significant differences between the groups. Following intervention, the pretest and posttest process and product scores were analysed using a multivariate analysis of variance (MANOVA) to detect significant interactions between the treatment (Independent Variables) and the process and product scores of the two handed side arm strike and the hockey hit (Dependent Variables). The basis of analysis of the process levels of both skills in component detail is presented.

Analysis of the Two Handed Side-Arm Strike

Video analysis was performed by employing a dichotomous scale based on the following criteria adopted from the Fundamental Motor Skill Manual (Victorian Department of Education 1996).

Process Criteria For The Two Handed Side Arm Strike:

1. Eyes are focused on the ball throughout the strike;
2. Preferred hand grips bat above non-preferred hand. (Hand position described at top of swing);
3. Stand side on to target;
4. Bat behind shoulder prior to downswing at the tee. (Adapted for tee from Walkley (1996) criteria 4);
5. Step towards target with foot opposite preferred hand during strike; and,
6. Marked sequential hip to shoulder rotation during strike.
7. Ball contact made opposite front foot with straight arms.
8. Follow through with bat around body.

NB: component four has been adapted from Fundamental Motor Skill Manual (Victorian Department of Education 1996) criteria. The basis of the choice to use a tee verses a pitcher was to control for the variability of the pitch. By using a tee, the environment became closed allowing the position of the ball to become predictable for all subjects.

Analysis of the Hockey Hit

Due to the lack of a validated instrument to measure the process components of the hockey hit, the following criteria were selected from the Aussie Sport Minkey Manual and validated
by two experts. Therefore, the qualitative outcome of the hockey hit was determined by scoring dichotomously the presence or absence of the following criteria.

Process Criteria For The Hockey Hit include:

1. Eyes focused on the ball throughout the hit;
2. Both hands grip the top of the stick - left hand above right but touching;
3. Stand side on, left shoulder facing target;
4. Backswing remains below shoulder height;
5. Step towards target - left foot in line with or slightly behind ball;
6. Transfer of weight from right to left foot (back to front foot), knees significantly bent during strike;
7. Ball contact made with stick at an angle to the ground of approximately 30-45 degrees;
8. Follow through with arms remaining straight and stick not exceeding shoulder height.

*Note - as all hockey sticks are right handed, left handed subjects must hit right handed.

After viewing the process of striking either as a fundamental motor skill or as a sport specific skill, a dichotomous rating was given to each criteria for each subject for each trial. Interrater reliability checks were made by employing the skills of a physical education teacher with fifteen years of teaching experience and a .90 rating was achieved over twenty subject codings. Moreover, a intrarater reliability check of .95 was achieved by recoding twenty subjects across pre and post tests.

RESULTS

Pretest Results

Following pretesting, random allocations were made to three groups. One way ANOVA was performed using the pretest scores of the two handed sidearm strike and the hockey hit, to detect differences. There were no significant differences across the groups. Further to three group matchings, a four week intervention ensued. Group one received four week unit of instruction from a range of fundamental motor skills; group two received instruction in hockey skills, and group three played the game of minkey. The intervention was designed to investigate the relative effect the instruction of fundamental skills, sport specific skill and the ‘control’ of play. The interaction of these forms of instruction was measured with a multivariate analysis of variance (MANOVA). There was no significant differences between the improvement males and female achieved through process scores due to forms of instruction. There was however, a significant difference in the pretest process scores on the two skills. These were males outperformed females in the fundamental skill of two hand side-arm striking and females outperformed males in the sport specific skill of the hockey hit. Details of the significant effect for gender is presented next in the pretest results.

Two Handed Side Arm Strike - Pretest.

A gender comparison of successful execution of qualitative criteria for the two handed sidearm strike is presented in Figure 1.

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Figure 1: Gender Comparison Of The Successful Execution Of Qualitative Criteria For The Two Handed Side-Arm Strike - Pretest (n=76).
Males outperformed females on a majority of the pretest two handed side-arm strike criteria. A higher percentage of male subjects successfully executed all criteria of the two handed side arm strike qualitative criteria compared to the female subjects. Two exceptions are noted. The first is criteria two where a higher percentage of females successfully gripped the bat with their preferred hand above their non-preferred hand (hand position described at top of swing) and the second is criteria one (eyes are focused on the ball throughout the strike) where an equal percentage of males and females successfully executed the component indicating a ceiling effect was evidenced on this criteria.

The following is a description of the components of the skill males outperformed females. Criteria three (standing side on to target), 91% of males and 80% of females were successful. Criteria four (bat held behind shoulder prior to downswing at the tee), 87% of males and 80% of females were completed. Criteria five (step towards target with foot opposite preferred hand during strike) resulted in successful execution of 53% of males and 52% of females. Criteria six (marked sequential hip to shoulder rotation during strike) males were all successful - 100%, compared to 93% of females. Criteria seven (ball contact made opposite front foot with straight arms) indicated successful execution for 78% of males and 66% of females whilst criteria eight (follow through with bat around body) results displayed a successful execution in 81% of males and 52% of females. Criteria five contained the lowest success rate of all criteria for males(45%) and females (43%).

Overall, the pretest results can be summarised as males outperforming females on five of the eight criteria. Females marginally outperformed males on criteria one and criteria two did not distinguish between the females and males. Additionally, one of these (criteria one) had a ceiling effect thus losing its function to discriminate. These results corroborate the trends suggested by Walkley et al. (1993) and Thompson et al. (1995), and confirm a cultural commonality in that Australian children are performing motor skills at comparable levels as the North American population (Kelly, Reuschlein & Haubenstricker 1990).

Hockey Hit - Pretest

A comparison of criteria completion on the basis of gender for the pretest hockey hit is displayed below in Figure 2.

Figure 2: Gender Comparison Of The Successful Execution Of Qualitative Criteria For The Hockey Hit - Pretest (n=76).

Females outperformed males on a majority of the pretest hockey hit criteria. The results displayed in Figure 2 show varying degrees of successful qualitative execution for the hockey hit. However, general trends show a higher percentage of females achieving successful execution in five of the eight criteria. Specifically: criteria four (backswing remains below shoulder height); criteria five (step towards target - left foot in line with or slightly behind ball); criteria six (transfer of weight from right to left foot, knees significantly bent during strike) and criteria eight (follow through with arms remaining straight and stick not exceeding shoulder height), females were superior. However, a higher percentage of males achieved a successful execution of criteria two (both hands grip the top of the stick - left hand above right hand but touching), criteria three (stand side on, left shoulder facing target), and criteria seven (ball contact made with stick at an angle to the ground of approx 30-45 degrees). A 100% successful execution for both males and females was achieved in criteria one (eyes focused on the ball throughout the hit) indicating a ceiling effect was present on this criteria.
Although not statistically significant, interesting contrasts can be made by comparing between genders, for the strike and the hockey hit, (males and females relative changes reported from post-testing results) Additionally, comparisons within gender of relative changes for females pre-testing to post-testing in the strike and the hockey hit and then the changes for males pre to post testing.

Between Gender Comparison Based on Post Test Results In order to detect changes in the qualitative measures of the strike and hockey hit, the following graphs depict the relative levels of performance of males and females on the post test data. These are simply the levels of successful completion with no statistical significance. Firstly, the comparisons of the posttest data of males and females will be presented for the two handed side arm strike, followed by the hockey hit.

Two Handed Side Arm Strike - Posttest

A comparison of criteria completion on basis of gender for the two handed side-arm strike posttest is displayed below in Figure 3.

Figure 3: Gender Comparison Of The Successful Execution Of Qualitative Criteria For The Two Handed Side-Arm Strike - Posttest (n=76).

The results data displayed in Figure 3 indicates that a higher percentage of male subjects completed a successful execution in six of the two handed side-arm strike qualitative criteria when compared to the female subjects. An exception to the trend is criteria two where a higher percentage of females successfully gripped the bat with their preferred hand above their non-preferred hand. Furthermore, criteria one (eyes are focused on the ball throughout the strike) is equal for males and females successfully executed the component indicating a ceiling effect was maintained on this criteria. Therefore, this criteria gave little to no discrimination over time.

Success rates of 100% were achieved by both male and female subjects in criteria one (eyes are focused on the ball throughout the strike) indicating a ceiling effect. Criteria two (preferred hand grips bat above non-preferred hand) results displayed a successful execution in 97% of males and 100% of females. Criteria three (standing side on to target) results indicated successful execution in 100% of males and 93% of females. Criteria four (bat held behind shoulder prior to downswing at tee) indicated successful execution in 87% of males and 73% of females. Criteria five (step towards the target with foot opposite preferred hand during strike) displays a successful execution in 87% of males and 77% of females. Criteria six (marked sequential hip to shoulder rotation during strike) results signal successful execution in 100% of males and 98% of females. Criteria seven (ball contact made opposite front foot with straight arms) indicates successful execution in 100% of males and 93% of females whilst criteria eight (follow through with bat around body) results indicated successful execution in 94% of males and 57% of females.

Overall, the posttest results can be summarised as males outperforming females on six of the eight qualitative process criteria. Females marginally outperformed males in criteria two whilst criteria one did not distinguish between males and females. The posttest process results for the two handed side-arm strike again conform to the trends suggested by Walkley et al. (1993) and Thompson et al. (1995), that the performance of male subjects was higher than female subjects in most fundamental skills.

Hockey Hit - Posttest
A comparison of criteria completion on the basis of gender for the hockey hit is displayed below in Figure 4.

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**Figure 4: Gender Comparison Of The Successful Execution Of Qualitative Criteria For The Hockey Hit - Posttest (n=76).**

The results data displayed in Figure 4 compare males and females on successful execution of the posttest hockey hit and indicate that females have generally outperformed males. A higher percentage of females than males achieved a successful execution of: criteria three (stand side on, left shoulder facing target); criteria four (backswing remains below shoulder height); criteria six (transfer of weight from right to left foot, knees significantly bent during strike); criteria seven (ball contact made with stick at an angle to the ground of approx 30-45 degrees); and, criteria eight (follow through with arms remaining straight and stick not exceeding shoulder height). Males achieved a successful execution in criteria two (both hands grip the top of the stick - left hand above right hand but touching), and criteria five (step towards target - left foot in line with or slightly behind ball). A 100% successful execution for both males and females was achieved in criteria one (eyes focused on the ball throughout the hit) indicating a ceiling effect was maintained on this criteria.

Within Gender (Female) Comparison of Process Results

A within gender comparison of the process results is of value to view the relative improvements the group acquired over the intervention period. Although not statistically significant, general trends can be viewed by initially viewing changes across time for females and later for males.

**Two Handed Side Arm Strike**

The comparison of the changes for females from pre to post testing in the eight criteria of the two handed side arm strike shows overall there is an improvement in all criteria except for criteria four.

Results presented in Figure 5 indicate declines in criteria four is indicative of the bat not being behind the shoulder prior to downswing at the tee. Fewer females were successful in this criteria from pretesting to post testing.

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**Figure 5: Pretest/Posttest Comparison Of The Two Handed Side-Arm Strike Process Criteria - Females.**

Overall, females improved in the majority of the qualitative criteria for the strike across the intervention. Females were outperformed by males on the pre and post testing of this skill and significantly in the pretesting reinforcing previous studies indicating males outperform females on motor skills requiring strength.

**Hockey Hit**
A pretest/posttest comparison of the female hockey hit process criteria is displayed below in Figure 6. This figure illustrates the relative changes across the intervention period and marks the changes in criteria for females.

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Figure 6: Pretest/Posttest Comparison Of The Hockey Hit Process Criteria - Females.

The results displayed in Figure 6 compare the pre and posttest hockey hit scores for females. Improvements in the percentage of females successfully executing the hockey hit are displayed in criteria three (stand side on, left shoulder facing target) with an improvement of 18%, criteria four (backswing remains below shoulder height) with an improvement of two percent, criteria five (step towards target - left foot in line with or slightly behind ball) with an improvement of 35%, criteria six (transfer of weight from right to left foot, knees significantly bent during strike) with an improvement of 16%, criteria seven (ball contact made with stick at an angle to the ground of approximately 30-45 degrees) with an improvement of 14% and criteria eight (follow through with arms remaining straight and stick not exceeding shoulder height) with an improvement of seven percent. Females continued to improve in all criteria except for criteria two.

Criteria two related to the grip on the top of the stick.

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Within Gender (Male) Comparison of Process Results Two Handed Side Arm Strike

A comparison of the male pretest and posttest two handed side arm strike process criteria is displayed below in Figure 7. Improvements in the percentage of males successfully executing the two handed side-arm strike are displayed in criteria two (preferred hand grips bat above non preferred hand) with a six percent improvement; criteria three (stand side on to target) with a nine percent improvement; criteria five (step towards target with foot opposite preferred hand during strike) with a 34% improvement; criteria seven (ball contact made opposite front foot with straight arms) with a 22% improvement; and criteria eight (follow through with bat around body) with a 13% improvement.

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Figure 7: Pretest/Posttest Comparison Of The Two Handed Side-Arm Strike Process Criteria - Male.

Males increased their rate of successful execution of the strike across the period of intervention (refer Figure 7). Criteria five (step toward the target with foot opposite preferred hand during strike) increased by the largest margin, however, improvements in criteria seven, and eight were also substantial.

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Hockey Hit
A comparison of the male pretest and posttest hockey hit process criteria is displayed below in Figure 8. The results displayed show the percentage of males successfully executing the hockey hit improved between the pretest and the posttest.

Improvements were indicated in all criteria except for criteria one where a ceiling effect was maintained and criteria two where a reduction of six percent was recorded. Improvements in other criteria ranged from six to fifty percent.

Figure 8: Pretest/Posttest Comparison Of The Hockey Hit Process Criteria - Males.

The results displayed in Figure 8 show that the percentage of males successfully executing the hockey hit improved between the pretest and the posttest. Exceptions are noted in criteria one (eyes are focused on the ball throughout the hit) where the ceiling effect remains and criteria seven (ball contact made with stick at an angle to the ground of approximately 30-45 degrees) where no change in proficiency levels was recorded in the pretest and the posttest whilst in criteria two (both hands grip the top of the stick - left hand above right but touching) a reduction of six percent in successful execution occurred between pretesting and posttesting.

Improvements in the percentage of males successfully executing the hockey hit are displayed in: criteria five (step towards target - left foot in line with or slightly behind ball) with an improvement of 50%; criteria six (transfer of weight from right foot to left foot, knees significantly bent during strike) with an improvement of 47%; criteria eight (follow through with arms remaining straight and stick not exceeding shoulder height) with an improvement of 19%; criteria three (stand side on, left shoulder facing target) with an improvement of 16%; and, criteria four (backswing remains below shoulder height) with an improvement of six percent.

CONCLUSION

In conclusion, this paper has presented significant effects for the pretesting scores of the two handed side arm strike with boys outperforming girls. Additionally, there was a significant difference in the process scores of the hockey hit with girls outperforming boys. Following the intervention, there were no significant interactions between the type of instruction and the change in process of either skills. Between gender comparisons showed that males improved on both skills and so did females. Within gender comparisons showed females improved in the majority of criterion for both the strike and the hit. Females achieved above 85% in five of the eight criteria in the posttest and six of the eight criteria for the hockey hit in the posttest were also above 80%.

Males continued to improve in the strike, achieving ceiling or 100% success in four of eight criteria and 80% or better in another three indicating a high level of process competence. The boys had a lower baseline of successful completion in the hockey hit and improved dramatically in four of the eight criteria.

It is interesting to note the relationship of criteria four where power
is required in both skills of striking and hockey hit. For the strike where the bat is to come to the shoulder for backswing, males outperformed girls on this in all tests, however, when this related criteria is viewed within a hockey context, it was imperative to keep the hockey stick below the shoulder. Interestingly, the girls had a higher success rate on this criteria when compared to the males for hockey, illustrating the knowledge of hockey rules could be a prerequisite to success in this criteria, or it could be girls do not bring the bat back far enough as in the strike and this translated into a success in the hockey context.

The Victorian Department of School Education (1996) has indicated through norm referenced testing that children should master each component of the two handed side-arm strike by a specific age and have mastered all by the age of nine. This instrument is not gender specific and results of this study contribute to the call for consideration of gender norms in these instruments (Hands and Larkin 1997).

The change over time for males showed overall trends towards improvement across both skills. All criteria with the exception of criteria two (both hands gripping the top of the stick) showed improvement. Females successfully executed more qualitative hockey hit criteria than males indicating performance levels of ten year old females are greater than ten year old males in this sample. The greater percentage of successful execution by females of the hockey hit may suggest a greater percentage of females regularly attend hockey coaching and playing sessions. Thomas and French (1985) suggest that differences in performance between males and females is environmentally induced, however, the exact cause for differences in this pretest and posttest is unknown. Of interest are the similar trends displayed for the pretest and the posttest of the hockey hit. Additionally, the lack of significant effect for three diverse types of instruction was a surprising finding.
REFERENCES


