C2-3 ID97

IT'S ABOUT HOW WELL YOU USE IT: SKATING STRIDE IN NOVICE, INTERMEDIATE AND ADVANCED INLINE SKATERS

Lucy Parrington[1,2], Paul Grimshaw[3] and Alec Buttfield[4]

[1]College of Sport and Exercise Science, Victoria University, Melbourne, Australia
[2]Institute of Sport, Exercise and Active Living, Victoria University, Melbourne, Australia
[3]School of Mechanical Engineering, University of Adelaide, Adelaide, Australia
[4]BioAlchemy Sports Consultancy, Adelaide, Australia

Adequate skating technique is imperative to roller sports. Characteristics that differ between inline skating competencies have not been addressed. This study assessed skating parameters associated with coaching cues across three levels of experience. Inline-skaters (n=24) were divided into novice, intermediate and advanced groups based on experience. Skate trajectories were captured through 3D analysis as participants skated maximally down a 10 m runway. One-way ANOVA was used to compare differences for the skating parameters between skill levels. Significant differences (P < 0.016) were found for stride-width, recovery, stride-width-recovery and stride-length-recovery and stride rate. Results have implications for delivery of coaching and skating skill development.

KEY WORDS: stride-width, stride-length, rollerblading, in-line, recovery

INTRODUCTION: Skating technique is integral to the performance of a number of roller sports (e.g. inline hockey, speed skating, roller derby, aggressive-street, recreational skating). Fundamentally, skating competency in these sports is a precursor to the ability to participate. In spite of this constraint, there has been little information dedicated to understanding the mechanics of inline skating. Research has predominantly focussed on injury epidemiology (e.g. review of injuries, Sherker & Cassell, 2002), rather than gaining an understanding of technical skating information that may indirectly reduce the incidence of injuries or enhance performance (Renger, 1994).

To the authors' knowledge, no work has been published examining the differences between novice, intermediate and advanced inline-skaters. Information may be extrapolated from the body of literature on ice skating technique (e.g. Roy, 1978; Upjohn, Turncotte, Pearsall, & Loh, 2008), which, on a practical level, has been indicated as possessing some technical similarities (Crawford & Holt, 1991; de Boer, Vos, Hutter, de Groot, & van Ingen Schenau, 1987). Albeit, ice skating studies provide a grounding for further investigation, but the inherent difference between factors such as the length of the blade versus wheel runner and the wheels-to-ground interaction versus the blade-to-ice interaction mean that direct comparisons should be interpreted with caution.

Evaluation of skating technique across three skill levels provides a reasonable approach in the exploration of developmental differences that occur through increased practice and participation. In addition, the measurement of kinematic parameters that can be associated with coaching cues supports an applied approach. Skating cues include encouraging the skater to 'push out as far as possible' with the propulsive leg; to 'pull the foot back under the body' during recovery of the pushing leg in preparation for the next stride; and to use a strong fluid push, rather than a 'short choppy stride' (D. Stromme, Coaching Director, personal communication, June 15, 2010). In ice skating research, Upjohn et al. (2008) found that high-calibre ice hockey players have a greater stride-width and stride-length than low-calibre players, but that both levels had similar stride rates. They suggested difference in maximum maintainable speed might be attributed to the recovery phase.

Technical analysis allows decomposition of the skill such that specific evidence-based information can guide and structure practice and/or learning conditions. Ultimately this assists teaching strategies, which may further promote development and/or refinement of skating skill. Additionally, knowledge on the changes required to improve skating technique may indirectly reduce injuries. The purpose of this study was to determine kinematic differences between novice, intermediate and advanced inline-skating technique. In particular, this study used skating parameters that could be related to coaching cues. Results have implications for coaches of the novice population in order to progress players quickly into a stable state, as well as benefits for players wishing to progress to the next level of their roller-based sport.

METHOD: Twenty-four inline skaters were recruited for this study. Participants were divided into three groups (novice, intermediate and advanced) based on experience. Participant height (stretch stature), mass, and standing leg length (trochanterion height) were measured by an anthropometric profiler and used in the normalisation of parameters. Participants were fitted with protective equipment (helmet, elbow, wrist and knee guards), and skates. All skates used during testing were four-wheel inline skates. A single marker was placed on the toecap of both skates to identify each of the skating related variables. A warm up period (at least five minutes) was provided for skaters to become accustomed to their gear and the testing conditions. Testing required participants to skate maximally in a straight line down a ten-metre runway. The capture area was aligned at the centre of this runway to ensure skaters were neither speeding up, nor slowing. Five successful trials were taken. A successful trial included at least one full stride and recovery recorded, and as indicated by the participant as a comfortable and representable performance. A six-camera VICON (100Hz, Oxford Metrics Group, Plc.) motion analysis system was used to capture the 3D position data. Data were reconstructed in VICON Workstation. Trajectory data of the left and right toe markers were exported into Microsoft Excel for processing. Maximum and minimum medio-lateral, and maximum and minimum anterio-posterior distance between the feet were calculated. Mean and standard deviation of the trials were calculated for each parameter (Table 1) and assessed across the three groups using a one-way ANOVA with post-hoc multiple comparisons performed in SPSS using Bonferroni corrected alpha ($P < 0.016$).

RESULTS: Table 1 provides descriptive data. Advanced skaters exhibited a greater stride-width ($d = 1.23$, $P > 0.016$) than novice skaters and a significantly greater stride-width in comparison to intermediate skaters ($P = 0.012$). Recovery distance was significantly greater in novice skaters in contrast to intermediate ($P = 0.003$) and advanced skaters ($P = 0.014$). Novice skaters had a significantly smaller stride-width-recovery, than both intermediate ($P < 0.001$) and advanced skaters ($P < 0.001$) and a significantly smaller stride-length-recovery compared to intermediate skaters ($P = 0.009$). Stride rate was significantly greater in novice skaters than in the intermediate ($P = 0.007$) and advanced skaters ($P = 0.009$)

Table 1: Kinematic parameters

Parameter	Definition		Mean	SD
Stride-width (m)	Maximum medio-lateral distance between the toe of the propulsive leg and the toe of the support leg, relative to leg-length (trochanterion height)	N:	0.52	0.07
		I:	0.51	0.07
		A:	0.60	0.06
Stride-length (m)	Maximum anterior-posterior distance between the toe of the propulsive leg and the toe of the support leg, relative to leg-length (trochanterion height)	N:	0.85	0.15
		I:	0.79	0.10
		A:	0.73	0.08
Recovery (m)	Minimum distance between the toe of the propulsive and support foot during stride recovery	N:	0.35	0.06
		I:	0.26	0.04
		A:	0.28	0.05
Stride-width-recovery	Stride width divided by stride recovery	N:	1.30	0.18
		I:	1.81	0.24
		A:	1.94	0.31
Stride-length-recovery	Stride length divided by stride recovery	N:	2.15	0.51
		I:	2.81	0.54
		A:	2.34	0.26

Parameter	Definition		Mean	SD
Stride rate	Number of strides completed in one second	N:	0.91	0.10
		I:	0.78	0.05
		A:	0.79	0.09

N: Novice, I: Intermediate, A: Advanced

DISCUSSION: 'Pushing out as far as possible' (i.e. fully extending the propulsive leg) has been used as a coaching cue for skaters to optimise each stride. This study assessed the distance between the support-leg foot and propulsive foot at push-off laterally (stride-width) and posteriorly (stride-length) to measure this. Values were then normalised to participant leg-length to avoid any inaccuracies resulting from player anthropometry. This method was conducted to reduce any artefact created by the distance travelled between subsequent strides or lateral excursion of the whole body. The advanced skaters exhibited a greater stride-width (mean = 0.6 m) in comparison to novice (mean = 0.52 m) and intermediate skaters (mean = 0.51 m), while stride-length did not differ between groups. The findings for stride-width are in agreement with Upjohn et al. (2008) who found larger stride-widths in high-calibre (mean = 0.64 m) in comparison to low-calibre ice hockey players (mean = 0.53 m). However, the stride-length findings are in contrast to Upjohn et al. (2008). The difference in the magnitude of the mean values can be attributed to the parameter definition as stride-length in Upjohn et al. (2008) was measured as the distance between two successive right foot push-offs and thus includes the distance travelled across the two strides. If higher calibre skaters are generating more work each stride, it follows that this distance and therefore stride-length measured, would be greater in this group. Pushing laterally has been advocated for ice-skating (de Boer et al., 1987; Roy, 1978). Studies indicate the lateral force component is enhanced as the angle of force application approaches and surpasses 45° (Marino, 1983). Since the angle at which the wheels interact with the ground surface change during stride, similar to ice skating, wider strides are likely to generate high propulsive forces (Roy, 1978). Advanced skaters are likely utilising the mechanical interaction between the width of their stride and lateral force production. Results from this study suggest functionally different strides across experience level, with decreases in both the mean value and within-group variation in stride-length associated with an increase in skating level. This indicates that as skill increases, players move from an inclination to push posteriorly, to a more efficient lateral push-off. Thus, it may be more practical benefit for coaches to address the extent to which a developing skater pushes laterally in contrast to simplifying the movement instruction as extending the propulsive limb. Figure 1 provides a diagram of stride characteristics.

The second coaching cue is for skaters to pull the foot to a position directly underneath the body during stride recovery. The larger recovery value in the novice skaters indicates that skaters in this group do not recover their feet to the same extent before propulsion of the opposing foot. Although Upjohn et al. (2008) did not measure stride recovery, they suggested that the recovery phase was connected to maximum maintainable skating speed. Stride-width and the application of lateral force may be important, but stride-width alone is not directly indicative of the total propulsive stride time. Considering the relationship between force and time of application, impulse and velocity, moving the propulsive limb over a greater range of motion should increase the distance that the wheels are in contact with the ground and therefore the time period of contact (Upjohn et al., 2008). Failure to bring the recovering foot to a position underneath the body would therefore compromise the range of motion available for the proceeding stride and detract from the benefits of a larger stride-width.

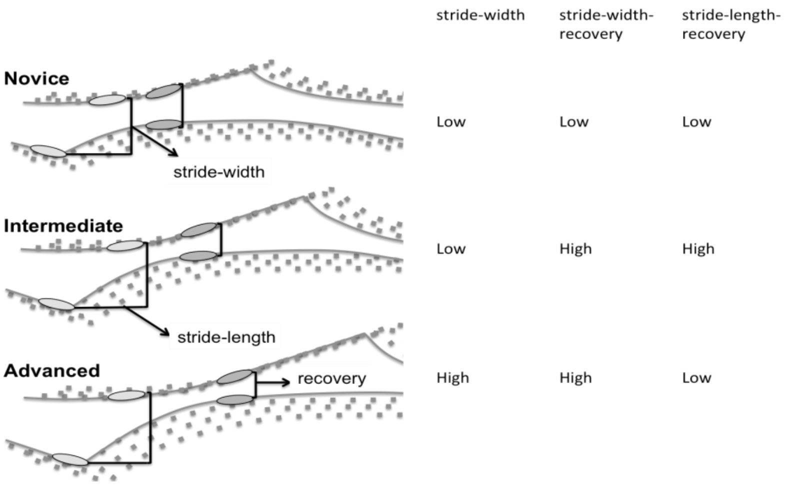

Figure 1: Stride and recovery characteristics

The relationship between recovery and leg extension laterally and posteriorly was quantified using stride-width and stride-length recovery. Novice skaters had a smaller stride-width-recovery than their intermediate and advanced counterparts and a smaller stride-length-recovery compared to intermediate skaters. Of interest, there appears to be a developmental pattern that emerges across the skill levels. Pushing laterally may be counterintuitive in early stages of learning because it challenges standard locomotion and skaters are likely to try to have a wider stance in attempt to increase balance. Novice skaters may initially progress by improved positioning of the recovering foot, reflected in the stride-width-recovery. At the intermediate level, propulsion is still directed posteriorly, but a more functional recovery position allows this group to have a greater stride-length-recovery. Technical progression may then be a function of increased lateral push matched with a reduction in posteriorly directed force. As a consequence the stride-length-recovery decreases again but the stride-width-recovery is maintained as the advanced skaters capitalise on the benefits of increased stride-width. If these changes are sequential in nature, then these findings have implications for coaches involved in the development of inline skating technique.

Stride rate was higher in the novice group, with more strides made for the novice skaters at maximum. These results are in contrast to Upjohn and colleagues (2008) who found no difference in stride rates. This is likely to a difference in task constraint, as skaters in Upjohn et al. (2008) were required to perform for a minute at maximum maintainable speed, while this study required skaters to perform a maximal effort sprint over 10 m.

Future directions include looking at other coaching relevant kinematic parameters such as knee flexion, as skaters are commonly told to bend their knees to gain power in their stride. Also, an intervention program to see which activities may increase the rate of skating expertise would be highly beneficial to ‘learn to skate’ programs

.

CONCLUSION: Stride-width was greater in advanced in contrast to the intermediate skaters. Novice skaters exhibited a poorer recovery, a lower stride-width-recovery, higher stride rate in comparison to the intermediate and advanced skaters and a lower stride-length-recovery compared to the intermediate skaters. For a proficient stride, players should focus on both returning the foot directly under their body and maximising their lateral push.

REFERENCES:

Crawford, R.J., & Holt, L.E. (1991). A kinematic comparison of on-ice power skating and off-ice rollerblade skating. In C.L. Tant, P.E. Patterson, & S.L. York (Eds.), *Proceedings from the 9th International Conference on Biomechanics in Sports*. USA: Iowa.

de Boer, R.W., Vos, E., Hutter, W., de Groot, G., & van Ingen Schenau, G.J. (1987). Physiological and biomechanical comparison of roller skating and speed skating on ice. *European Journal of Applied Physiology*, *56*, 562-569.

Marino, G.W. (1983). Selected mechanical factors associated with acceleration in ice skating. *Research Quarterly, 54*(3), 234-238.

Renger, R. (1994). Identifying the task requirements essential to the success of a professional ice hockey player: A scout's perspective. *Journal of Teaching in Physical Education*, *13*, 180-195.

Roy, B. (1978). Biomechanical features of different starting positions and skating strides in ice hockey. In E. Assmussen & K. Jorgeusen (Eds.), *Biomechanics VI-B* (pp. 137-141). Baltimore: University Park Press.

Sherker, S. & Cassell, E. (Eds.). (2002). *In-line skating injury: A review of the literature.* (Accident Research Centre Report). Melbourne, Australia: Monash University.

Upjohn, T., Turncotte, R., Pearsall, D.J., & Loh, J. (2008). Three-dimensional kinematics of the lower limbs during forward ice hockey skating. *Sport Biomechanics*, *7*(2), 206-221.

Acknowledgement:

The authors would like to thank Gordon Young and Matt Helmers of Skate Australia and the South Australian Sports Institute for use of their facilities.