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Kinematical Analysis of the Turn Transition Phase of the Snowboarders' Carving Turn

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Abstract

The purpose of this study was to analyze the kinematical variables in different phases of alpine snowboarders' carving turn. Moreover, the study aims to improve the athletic performance and prevent injury through comparative analysis of different kinematical factors. To achieve the purpose of the study, four alpine snowboarders from Korean National Team for 2018 Pyeongchang Winter Olympics were chosen. For those time duration, distance, velocity and angular variables were calculated. The following conclusions were drawn: The overall elapsed time appeared to have greater significance in P1 than in P2. The displacement in the CM per event increased as a whole in medial-lateral displacement from E1 to E3. Forward-backward displacement results appeared similar in all of the subjects. Increasing trend in upward-downward displacement appeared in all the subjects. Furthermore, in E2 peak point in displacement could be observed which gradually decreased later. Velocity of CM in each event appeared to be the fastest in medial-lateral velocity and Forward-backward velocity in E2. Upward-downward velocity appeared the fastest in E3. The board's velocity appeared the fastest in E1 however its velocity appeared the lowest in E2. Angle of ankle joint and angle of knee joint per event appeared the lowest in E2. Angle of hip joint and the angle of board- hip and shoulder's twist appeared the lowest in E3.

Keywords: *Kinematical analysis, snowboarder's carving turn, transition phase, center of mass (CM)*

1. Introduction

Snowboarding is now one of the most popular winter sports among youth around the world. Snowboarding has shown an explosive growth since its first introduction in late 1990s in Korea. Since then the numbers of snowboarders has increased a lot than skiers which can be easily noticed in slopes around different resorts in Korea making it one of the most popular winter sporting event. It has been an official sports in the Winter Olympics since the 1998 Winter Olympics Nagano, Japan. A total of four snowboarding event including slope style will be held at 2014 Winter Olympics Sochi, Russia.

The technical phase of a snowboard turn starts from the traverse up and unweighting the pressure down through the fall line. Different stances and balance are used for various centering situation. Steering, rotation, pivoting are used to change the direction of the board; edging and turns can be achieved by combination of inclination and angulation. (Canadian Association of Snowboard Instructors, 2000; Hyun-dae Jo, 2011)

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Depending on the slope angle, speed and terrain condition, angle of inclination and unweighting for turn as well as pressure varies. Both skiing and snowboarding requires similar basic turn principles with up-down movements as well as requires tilting to bear the centrifugal force and shows similar pattern of angulation for increasing the edge angle as in cycling.

Carving turn is a technique in which riders initiate the turn by increasing the arc of the board to the surface and by leaving a precise slice carved arc in the snow. In carving turns, point of pressure that is conveyed to the board becomes slightly faster than in basic turns. Increment in the force applied to the board increase the pressure between the board and surface which presses the surface of the board and makes it dig deeper into the snow. Unweighting reduces the amount of weight on the board which decreases friction from the snow surface moreover, releases the board from pressure and resistance of the snow.

In the turn transition phase, edge change is conducted on the board surface to perform next turn in the desired directions. Thus, there is a need for kinematical analysis to analyze the turn transition phase in the carving turn. Even though very few kinematical analysis has been conduct for the snowboard turn, kinematical analysis of the turn transition phase doesn't exist.

The purpose of this study is to analyze the motion pattern and behavior in each segment of alpine snowboarders' carving turn i.e. the displacement of the snowboarder's center of mass, velocity and the joint angle. Moreover, this paper focuses on the potential to improve the snowboarders' performance by comparative analysis of different kinematical factors through a three -dimensional kinematical comparative analysis method

2. Method

In this paper, three dimensional motion analysis (3D) was conducted using Direct Linear Transformation (DLT) method of which kinematic factors in Turn Transition phase of alpine snowboarder's carving turn were analyzed.

2.1. Subjects

Four alpine snowboarders from Korean National Team for 2018 Pyeongchang Winter Olympics participated in the experiment. Physical characteristics of the study participants are presented in Table 1.

Table 1. Physical Characteristics of the Participants

Subjects	Height (cm)	Weight (kg)	Age	Skill level (year)
S1	173	71	20	6
S2	174	64	19	6
S3	170	63	18	4
S4	178	76	19	6
M±SD	173.75±3.30	68.5±6.14	19±0.82	5.5±0.87

2.2. Experimental Procedures

The test took place in the advanced ski slope at P ski resort, Kangwondo Korea. A three dimensional rectangular 11m (width), 2m (length), and 2m (height) calibration frame was constructed and positioned properly to capture and cover the spatial coordinates of the points of the entire turn as well as transition phase from the camera's field of view, their motions were recorded using two video cameras of 1.5m (height) which were simply slotted into the tripods. Test recording were conducted for 30 second to 1 minute. The experimental slope was 866m in length at an altitude of 238.7m with average pitch of 15.41 to maximum pitch of 36.0° in the advanced course. The subjects performed two runs in a twenty four gates (Giant slalom Course) of which best turns were selected for analysis. The distance between each gate was about 22m.

The runs were recorded at 30frames/sec. The time interval of analysis was processed and rearranged at 1/100 of a second due to the possibility of each frame could be divided into two fields of actual speed of 60fields/sec. Before filming the turns, the experimental procedures and possible risks were communicated verbally and in writing to all study participants, who then gave their informed written consent. The participants were allowed enough time to warm up and time to do two test run to familiarize with the slope conditions and to ensure actual competition condition.

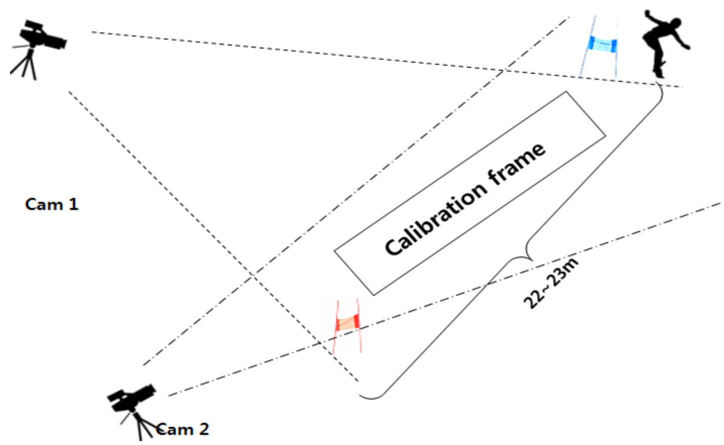

Figure 1. Placement of the Experimental Equipments

2.3. Data Analysis

The data acquired were processed using Kwon3D 3.1(Kwon, 2005). For digitizing the coordinates of the calibration frame, bottom of the right side and the back side of the pole were selected as reference point. A total of 84 coordinate points were selected for analysis. The direction in which the participant descend passing through the gate was selected as Y axis. While descending, vertical progress direction was selected as Z axis, Left and right direction was selected as X axis i.e. the vector product from Z axis to Y axis.

Central body joint coordinates is defined as a rigid body system of 23 coordinates of human body model and 16 body segments connected to it. Body segment parameters (Chavdler 1975) were referred to calculate the CM and Position of CM in different segments.

2.4. Definition of Event and Phases

The selection of event and phase in the turn transition phase in carving turn of alpine snowboarder are presented in Figure 2.

2.4.1. Definition of Event:

E1: Starting point of Extension (UP)
E2: Complete contact point of deck surface to the ground surface.
E3: Point of Complete flexion (down)

Figure 2. Classification of Movement in Different Events

2.4.2. Definition of Phases: P1 (Phase 1): From E1 to E2
P2 (Phase 2): From E2 to E3

3. Results and Discussion

This study was conducted on alpine snowboarder's from Korean National Team for 2018 Pyeongchang Winter Olympics. Video analysis was performed to analyze the kinematical factors in snowboarder's turn transition phase in carving i.e. the displacement of center of mass (CM), velocity of CM, angle of joint, elapsed time, distance, velocity and angular variables.

3.1. Elapsed Time Variable

The elapsed time in different phases of turn transition phase in carving turn is presented in Table 2 and the percentage of elapsed time in phases in accordance with the total elapsed time of each player is presented in Figure 3.

Table 2. Time Elapsed in Different Phase [sec]

Subjects	**P1**[sec]	**P2**[sec]	**Total** [sec]
S1	0.27	0.23	0.50
S2	0.43	0.27	0.70
S3	0.40	0.10	0.50
S4	0.43	0.33	0.77

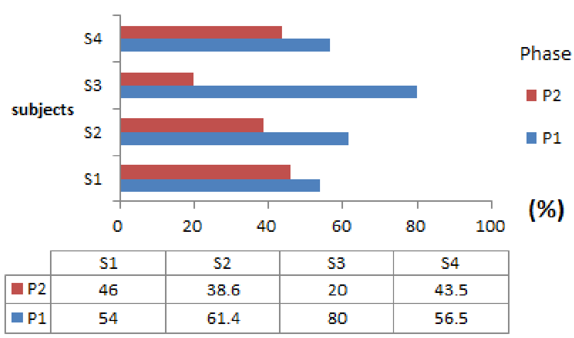

Figure 3. Percentage of Total Elapsed Time (%)

Time elapsed in each phase were divided into two phases P1 (starting point of extension (up) to complete contact point of deck surface to the ground surface) and P2 (from complete contact point of deck surface to the ground surface to point of complete flexion (down). S1 measured 0.27 sec in P1 and 0.23 sec in P2, with total elapsed time of 0.50 sec. S2 measured 0.43 sec in P1 and 0.27 sec in P2, with total elapsed time of 0.70 sec. S3 measured 0.40 sec in P1 and 0.10 sec in P2, with total elapsed time of 0.50 sec. S4 measured 0.43 sec in P1 and 0.33 sec in P2, with total elapsed time of 0.77 sec. In a study conducted by Seok Hwan Yoon (2007) related to Dynamic analysis and scientific education effect of Snowboarding, Lowering the center of gravity at once changes the potential energy stored in the snowboarder which increases the speed instantaneously and gets changed into liner motion. In this process of change to kinetic energy, the snowboarder cannot execute the rotation thus misses the turn. Therefore, the center of gravity while snowboarding should be lowered slowly.

3.2. Distance Variable

The results of displacement of CM in the turn transition phase of carving turn in alpine snowboarding was divided into different events which are presented in Table 3 and their patterns in Figure 4.

Table 3. Displacement of CM [m]

Subjects	Variable	E1	E2	E3
S1	X	-1.35	-0.69	0.1
	Y	5.07	9.22	13.72
	Z	0.55	0.85	0.81
S2	X	0.69	1.11	1.46
	Y	-3.01	3.54	9.91
	Z	0.48	0.86	0.71
S3	X	1.06	2.04	2.73
	Y	-2.44	3.05	8.7
	Z	0.56	0.74	0.58
S4	X	1.35	1.92	1.96
	Y	-2.52	3.74	11.27
	Z	0.63	0.86	0.61

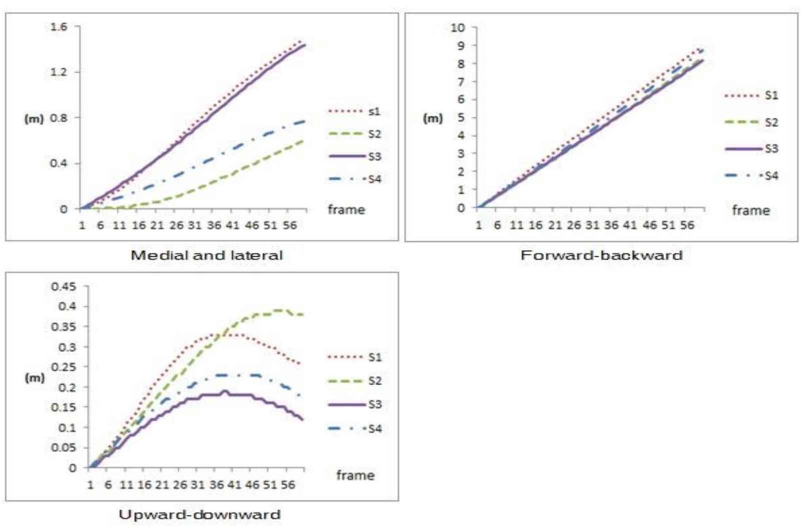

Figure 4. Displacement of CM

Medial and lateral displacement of CM appeared -1.35m in E1 and 0.1m in E3 of S1,-0.69m in E1 and 1.46 in E3 of S2, 1.06m in E1 and 2.73m in E3 of S3, 1.35m in E1 and 2.73m in E3 of S4. Thus, as a whole gradual increment in value was observed while approaching E3 from E1. The increment in value was considered due to the displacement from medial to lateral.

The forward-backward displacement of CM in E1 appeared 5.07m in S1,-3.01m in S2, -2.44m in S3 and -2.52m in S4, in E3, it was 13.72m in S1, 9.91m in S2, 8.7m in S3 and 11.27m in S4. The distance in each event from E1 to E3 appeared as 8.02m in S1, 12.92m in S2, 11.14m in S3 and 13.97m in S4.

The upward-downward displacement of CM was 0.85m in E2 of S1, 0.86m in E2 of S2, 0.74min E2 of S3 and 0.86m in E2 of S4, where highest value of upward-downward displacement was observed respectively in all subjects. Thus, the following results can be interpreted as, increment in CM of the body appeared due to release in the pressure exerted by the board during extension motion in the previous turn and decrement in CM appeared due to repressurization on the board during the first half of the turn during flexion motion.

3.3. Velocity Variable

The results of velocity of CM and board in the turn transition phase of carving turn in alpine snowboarding was divided into events which are presented in Table 4 and their patterns in Figure 5.

Table 4. Velocity of CM [m/s]

Subjects	Variable	E1	E2	E3
S1	**X**	1.01	3.05	2.17
	Y	15.68	15.14	14.85
	Z	0.89	0.73	-0.54
	Board	16.04	14.17	14.78
S2	**X**	0.01	1.56	-0.74
	Y	13.51	14.67	14.44
	Z	0.91	0.25	-0.44
	Board	15.11	14.2	14.54
S3	**X**	2.02	2.74	0.03
	Y	13.68	13.83	14.23
	Z	0.74	-0.08	-0.4
	Board	13.98	13.56	14.4
S4	**X**	0.9	1.5	-2.07
	Y	14.16	15.12	14.17
	Z	0.87	-0.09	-0.46
	Board	14.71	14.61	14.06

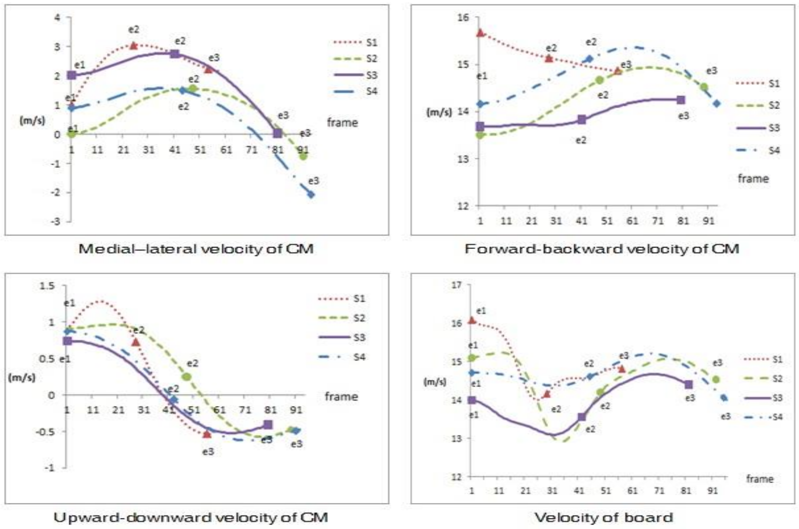

Figure 5. Velocity Variable

The value of medial –lateral velocity of CM appeared the highest in E2 in all of the subjects. The fastest velocity recorded in E2 appeared as 3.05m/s in S1, 1.56m/s in S2, 2.74m/s in S3 and 1.5m/s in S4. The result obtained can be interpreted as a process for stabilization after completing the previous turn and as a characteristics for increasing the edging and angle of inclination in order to control the increased speed.

The forward-backward velocity appeared 15.68m/s in E1 and 14.85m/s in E3 of S1, 13.51m/s in E1 and 14.44m/s in E3 of S2, 13.68m/s in E1 and 14.23m/s in E3 of S3, 14.16m/s in E1 and 14.17m/s in E3 of S4 where most of the subjects showed faster velocity in E3 than in E1.

The upward-downward velocity of CM appeared the highest value as a whole in E1 and appeared the lowest in E3. In E1, it was 0.89m/s in S1, 0.91m/s in S2, 0.74m/s in S3, 0.87m/s in S4 and in E3, it was –0.54m/s in S1, –0.44m/s in S2, –0.4m/s in S3, –0.46m/s in S4. Increased velocity was observed in the board due to releasing of pressure in the previous turn during extension motion than in pressure exertion during flexion motion.

The velocity of board for S1 appeared 16.04m/s in E1, 14.17m/s in E2, 14.78m/s in E3. For S2, it appeared 15.11m/s in E1, 14.2m/s in E2, 14.54m/s in E3. For S3, it was 13.98m/s in E1, 13.56m/s in E2, 14.4m/s in E3. For S4, It was 14.71m/s in E1, 14.61m/s in E2, 14.06m/s in E3. The velocity of the board showed tendency of gradual decrement from E1 to E2. However, increment in velocity was observed while approaching to E3. Excluding S1, the velocity of rest of the subjects appeared the fastest in P1 than in P2.It is considered due to the reduction in pressure applied to the board, the surface resistance decreased too which increased the velocity of the board. According to KSIA Committee of Snowboard (2004), In order to control the speed of the board during pivoting the time elapsed should be minimized in vertical descend and the speed can be controlled by complete rotation during uphill turn.

3.4. Angular Variable

Angle of lower limbs joint, angle of hip joint and the angle of board-hip and shoulder's twist in the turn transition phase of carving turn of alpine snowboarding were divided into events which are presented in Table 5 and their patterns in Figure 6.

Table 5. Angular Variables [deg°]

Subjects	Variable	E1	E2	E3
S1	Ankle	114.44°	66.59°	89.37°
	Knee	121.31°	102.87°	99.52°
	Hip-joint	142.25°	105.18°	103.72°
	Board- shoulder	62.06°	62.68°	71.33°
	Board- hip	57.33°	45.64°	69.8°
S2	Ankle	105.45°	67.6°	99.7°
	Knee	141.08°	103.93°	114.33°
	Hip-joint	105.95°	122.84°	94.2°
	Board- shoulder	102.93°	69.72°	75.61°
	Board- hip	52.34°	62.77°	75.48°
S3	Ankle	106.61°	121.23°	146.9°
	Knee	127.45°	138.15°	128.81°
	Hip-joint	87.57°	96.43°	107.44°
	Board- shoulder	101.49°	123.48°	105.94°
	Board- hip	101.55°	113.84°	104.04°
S4	Ankle	51.87°	53.96°	101.91°
	Knee	103.92°	89.98°	108.98°
	Hip-joint	150.9°	125.44°	107.11°
	Board- shoulder	58.79°	66.34°	76.91°
	Board- hip	58.85°	61.4°	73.03°

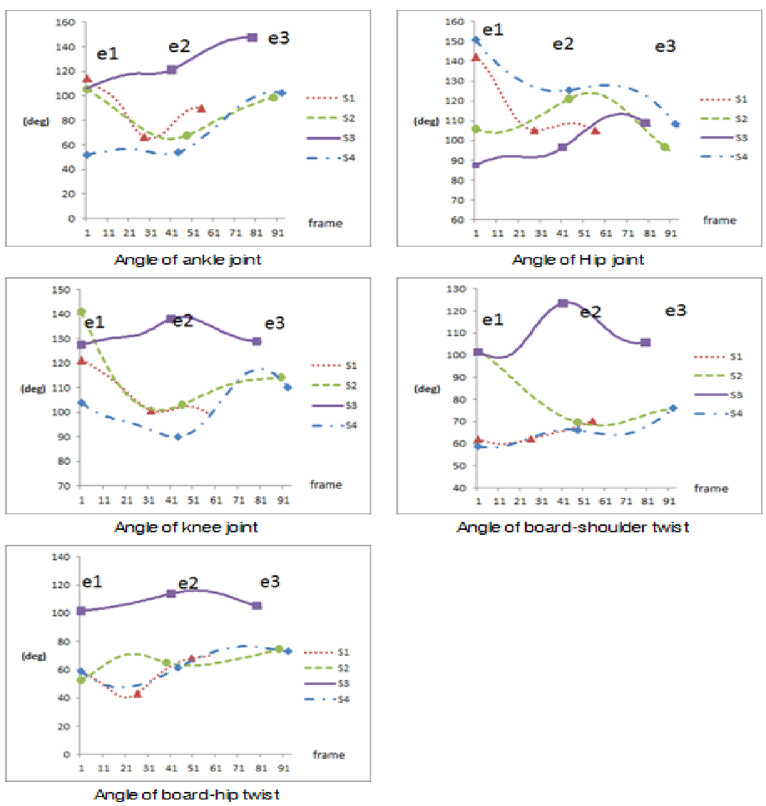

Figure 6. Angular Variable

The angle of ankle joint appeared as in Table 5, 114.44° in E1, 66.59° in E2, 89.37° in E3 of S1 subject, 105.45° in E1, 67.6° in E2, 99.7° in E3 of S2 subject, 106.61° in E1, 121.23° in E2, 146.9° in E3 of S3 subjects, 51.87° in E1, 53.96° in E2, 101.91° E3 of S4 subject. Overall, angle of ankle joint in all of the subjects appeared greater in E3 than in E2. Increment in the angle of ankle joint is considered due to the continuation of the back side turn following the previous turn where inclination of CM occurred in response to centripetal force to overcome the centrifugal force.

The angle of knee joint appeared as in Table 5 for S1 (121.31° in E1, 102.87° in E2, 99.52° in E3), S2 (141.08° in E1, 103.93° in E2, 114.33° in E3), S3 (127.45° in E1, 138.15° in E2, 128.81° in E3), S4 (103.92° in E1, 89.98° in E2, 108.98° in E3). In a study conducted by Hyundae Jo (2011) the angle of ankle joint and knee angle generally appeared low in experienced instructors than in beginner snowboard instructors in snowboarding turn.

The angle of Hip joint appeared as in Table 5 for S1 (142.25° in E1, 105.18° in E2, 103.72° in E3), S2 (105.95° in E1, 122.84° in E2,94.2° in E3), S3 (87.57° in E1, 96.43° in E2, 107.44° in E3), S4 (150.9° in E1, 125.44° in E2, 107.11° in E3). Excluding S3, angle of hip joint in rest of the subjects appeared lowest in E3 than in E1. According to Hyundae Jo (2011), pivoting and rotation is needed while skidding to reduce the friction between snow and the board surface. Moreover, the radius of the turn is determined according to the trajectory of the side-cut and through angulation the board moves in the direction of the side-cut which is the propensity of the carving turn.

Angle of board-shoulder and angle of hip-twist represents the degree of twist of the upper and the lower body which is executed in order to create pure carved turns from the current turn to the next turn. The angle of board-shoulder twist appeared as in Table 5 for S1(62.06° in E1, 62.68° in E2, 71.33° in E3), S2 (102.93° in E1, 69.72° in E2, 75.61° in E3), S3 (101.49° in E1, 123.48° in E2, 105.94° in E3), S4(58.79° in E1, 66.34° in E2, 76.91° in E3).

The angle of board-hip twist appeared as in Table 5 for S1 (57.33° in E1, 45.64° in E2, 69.8° in E3), S2 (52.34° in E1, 62.77° in E2, 75.48° in E3), S3 (101.55° in E1, 113.84° in E2, 104.04° in E3), S4 (58.85° in E1, 61.4° in E2, 73.03° in E3).

Thus, excluding S3, the angle of board-shoulder and angle of hip-twist, appeared greater in E3 than in E1 in rest of the subjects. The result obtained is considered due to occurrence of crossover when the center of gravity and the board proceed to the arbitrary line *i.e.*, during the point of intersection of the trajectory of the carved turn. The purpose of the crossover in carving is for easier preparation and coordination during the start of rotation to ride the edge changing phase easily and smoothly through applying pressure on the front part of the board which increases the angle of edge rapidly (Deok-yong Kim and Jae-heon Song, 2001).

4. Conclusion

Comparative analysis was performed on alpine snowboarder's turn transition phase in carving turn where various kinematical variable i.e. distance variable, time variable, velocity variable, angular variable were analyzed and described to promote better understanding of the alpine snowboard turn. The conclusion of the comparative study and suggestions are as follows:

In time variable, higher percentage of total elapsed time appeared in P1, which is considered due to the reduction of weight during extension and having sufficient time for flexion which is needed for the rapid transition before the start of next turn.

In the distance variable, gradual increment in value of CM in medial-lateral displacement was observed while approaching E3 from E1. The CM of forward- backward displacement from E1 to E3 in each event appeared relatively the shortest in S1 (8.02m) however; S4 (13.97m) appeared the furthest in each event. The delay in events in S1 than S4 is considered due to the influence of previous turn where slipping occurred which consequently decreased the speed. In the upward-downward displacement of CM following results can be interpreted as, increment in CM of the body appeared due to release in the pressure exerted by the board during extension motion in the previous turn and decrement in CM appeared due to the re pressurization on the board during the first half of the turn during flexion motion.

The value of medial –lateral velocity of CM in E2 appeared the highest in all of the subjects. The result obtained can be interpreted as a process for stabilization after completing the previous turn and as a characteristics for increasing the edging and angle of inclination in order to control the increased speed. The forward-backward velocity in E3 appeared fastest in most of the subjects than in E1. The value of upward-downward velocity of CM in E1 appeared the highest as a whole and appeared the lowest value in E3. Increase in velocity was observed in the board due to the release in pressure in the previous turn during extension motion than in pressure exertion during flexion motion. The velocity of the board showed tendency of gradual decrement from E1 to E2. However, increment in velocity was observed while approaching to E3. It is considered due to the reduction in pressure applied to the board, the surface resistance decreased too which increased the velocity of the board.

In angular variable, the overall angle of ankle joint appeared greater in E3 than in E2 Increment in the angle of ankle joint is considered due to the continuation of the back side turn following the previous turn where inclination of CM occurred in response to centripetal force to overcome the centrifugal force. The angle of knee joint from E2 to E3 showed tendency of low value only in two subjects. Angle of hip of S1, S2, S4 appeared lowest in E3 than in E1 excluding S3 which is considered due to the pivoting and rotation which increased the angulation. Excluding S3, the angle of board-shoulder and angle of hip-twist, appeared greater in E3 than in E1 in rest of the subjects. The result obtained is considered due to occurrence of crossover when the center of gravity and the board approached the arbitrary line *i.e.*, during the point of intersection of the trajectory in the carved turn. Crossover is important technique because it avoids resistance during the edging by preventing the board from slipping during the start of rotation. Moreover, it also rapidly searches the down weighting point by pressing the board which decreases the resistance when passing through the fall line and maintains balance and speed.

In conclusion, during P1 phase sufficient time for flexion is needed for the rapid transition before the start of next turn. Moreover, the result obtained is considered as a characteristic for increasing the edging and angle of inclination through which rotation and pivoting occurred in order to control the increased speed. In addition, Inclination arises in order to overcome the centrifugal force and the center of gravity shifts from the right to the left which is considered as a result to control speed while snowboarding. In the future, more researches on the characteristics of the turn transition phase as well as the turn in alpine snowboarding is required which plays a vital role in affecting the performance of the athlete.

References

[1] V. Aleshin, S. Klimenko, M. Manuilov and L. Melnikov, “Alpine skiing and snowboard training system using induced virtual environment”, Science and Skiing IV, **(2008)**, pp. 137-44.

[2] K. Byung-jong and Y. S. Lee, “A Study on the Measuring EMG Signal Using Two-Dimensional images of the Fatigue analysis”, Dept. of Digital broadcasting and Electronics Eng., Chungwoon University, Journal of the Korea Academia-Industrial cooperation Society, **(2009)**, pp. 1010-1013.

[3] Canadian Association of Snowboard Instructors, Canadian Association of Snowboard Instructors guide book, www.casi-acms.com, **(2000)**.

[4] C. Han, S. Kim and C. Oh, “The Study of Improving the Accuracy In the 3d Data Acquisition of Motion Capture System”, IJ, Control and Automation, SERSC, vol. 2, **(2009)**, pp. 49-58.

[5] C. geun Han, Snowboard Manual Power Book, SAM-HO Media publishing CO, Korea, ISBN: 89-7849-079-4, **(1996)**.

[6] C.-H. Lee and K.-J. Nam, "Analysis of the Kayak Forward Stroke According to Skill Level and Knee Flexion Angle", IJ. Bio-Science and Bio-Technology, SERSC, vol. 3, **(2011)**, pp. 41-48.
[7] D.-Y. Kim and J.-H. Song, "Snowboarding with Professionals", Daesun publishing, Korea, ISBN: 89-88944-41-0 93690, **(2004)**.
[8] J. Hyun-Dae, "The Kinematic Comparative Analysis of the Snowboard turn", Postgraduate thesis, Graduate School of Korea National University of Education, Korea, **(2011)**.
[9] Korea Ski Association Snowboard Committee, Korea Ski Association Snowboard Instructor Text Book (2004), http://www.ksia.co.kr/, vol. 2, pp. 50.
[10] M. Tarokh and M. Lee, "Systematic Method for Kinematics Modeling of Legged Robots on Uneven Terrain", IJ. Control and Automation, SERSC, vol. 2, **(2009)**, pp. 9-18.
[11] R. Kouskouridas and A. Gasteratos, "Location Assignment of Recognized Objects via a Multi-Camera System", Signal Processing, Image Processing and Pattern Recognition, SERSC, vol. 4, **(2011)**, pp. 1-18.
[12] S. Jo Han and S.-U. Kim, "Comparison of Peak EMG Amplitude on Low Back Muscles according to Asymmetric Load Center of Gravity and Trunk Lateral Bending while Lifting,Department of Industrial Engineering", Dankook University, Journal of the Korea Academia-Industrial cooperation Society, http://dx.doi.org/10.5762/KAIS.2012.13.10.4629, vol. 13, **(2012)**, pp. 4629-4635.
[13] S.-H. Cho and S.-G. Kim, "The Effect of Depending on Variations of Speed in Backward Walking on Lower Extremities Muscle", Dept. of Rehabilitation Science, Graduate School of Daegu University, Journal of the Korea Academia-Industrial cooperation Society, http://dx.doi.org/10.5762/KAIS.2012.13.5.2199, vol. 13, **(2012)**, pp. 2199-2205
[14] H. Sodeyama, M. Mirua, Y. Ikegami, K. Kitamura and H. Matsui, "Study of displacement of a skier's center of gravity during a ski turn", BIOMECHANICS VB, University Park Press, Baltimore, **(1979)**, pp. 271-276.
[15] Y. Suk-Hwna, "Dynamic analysis and scientific education effect of Snowboard", Postgraduate thesis, Department of Physics Education, the graduate School of Education, Hankuk University of Foreign Studies, Korea, **(2007)**.

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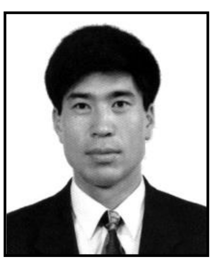

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