Robert C. Reid

A kinematic and kinetic study of alpine skiing technique in slalom

Appendices

DISSERTATION FROM THE NORWEGIAN SCHOOL OF SPORT SCIENCES • 2010

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APPENDIX A. Athlete Information

Athlete Information

Thank you for your interest in participating in my studies. As you may know, I am a Ph.D. student at the Norwegian School of Sport Sciences. My project is entitled "A study of the key aspects of modern alpine ski racing technique and their relationship to performance." My primary goal is to deepen our understanding of alpine skiing technique, in particular turning technique, and how this relates to performance. I intend to have a rather "practical approach" with the hope that the results of this work will have an immediate and practical benefit to the coaches and athletes in the Norwegian Ski Federation. I have until October, 2008 to complete this project.

Research Questions

This on-going project is divided into a series of smaller studies to be completed over the next few years. The particular study for which I am asking your participation will examine several interesting questions in regard to turning technique. In general terms, these are the following:

1. How do skiing line and degree of steering at the start of the turn relate to performance in varying course, terrain, and snow conditions?
2. How does the degree of for / aft movement through a turn relate to performance in varying course, terrain, and snow conditions?
3. How does the degree of up / down movement through a turn relate to performance in varying course, terrain, and snow conditions?

Methods

To examine these questions, we will use primarily a method referred to as "close-range photogrammetry." This method involves filming a section of a course from 4 to 5 different camera angles. These video images can then be used to create a 3 dimensional model of your actions. Then, this model can be used to quantify numerous aspects of your performance so that we can study the above stated questions. In cooperation with your coaching staff, we have planned a series of studies in various terrain and course setting situations.

These studies should not interfere with normal training. The main difference that you will notice is that there will be placed so-called "control points" on the hill surrounding the section of the course we intend to examine. These control points will be placed at a safe distance from the line and are constructed of safe materials (foam).

In addition to filming, we will need to measure various lengths and circumferences of your body so that we can accurately estimate where your center of mass is located. These measurements take approximately one hour.

Confidentiality

Participation in this study is confidential. You will be assigned a reference number that will be used in all references – both electronic and written - to the your data. At the completion of the study, the list of reference numbers, names and data collection forms will be destroyed. However, since the video recordings of the athlete's skiing are an important part of the results, these will be saved.

Risks

Risks with participation in this study are minimal. The only additional risk beyond that experienced in normal training situations are the control points that are placed on the hill. However, these are not only constructed of safe materials, but will also be placed at a safe distance from the line.

Benefits

In terms of benefits, these studies are being conducted in collaboration with your coaching staff. It is hoped that through these studies we will deepen our understanding of the fundamental principles of turning technique and how these relate to performance. Additionally, you will receive copies of resulting reports as well as access to data that may assist you in your technique training. Finally, certain components of the information assimilated in this project may be useful in developing documents for the coach's education programs in the Norwegian Ski Federation.

Participation in this study is voluntary and you have the right to withdraw at any point without having to give a reason. If you should decide to withdraw from the study, all collected information to that point will be destroyed.

This study is registered with the Ombudsman for Privacy in Research, Norwegian Social Science Data Services AS.

If you have any questions or concerns, please feel free to contact one of the following:

Contacts:

Robert C. Reid (Ph.D. student)
The Norwegian School of Sport Sciences
P.O. Box 4014 – Ullevål Stadion
NO-0806 Oslo
Norway
Email: robert.reid@nih.no
Mobile: +47 97 18 45 28

Per Haugen (advisor)
The Norwegian School of Sport Sciences
P.O. Box 4014 – Ullevål Stadion
NO-0806 Oslo
Norway
Email: per.haugen@nih.no
Telephone: +47 23 26 20 00

Gerald Smith (advisor)
The Norwegian School of Sport Sciences
P.O. Box 4014 – Ullevål Stadion
NO-0806 Oslo
Norway
Email: **gerald.smith@nih.no**
Telephone: +47 23 26 20 00

Again, thank you for your participation and interest.
Sincerely,

Robert C. Reid

APPENDIX B. Informed Consent Form

INFORMED CONSENT

Project Title:
"The key aspects of modern alpine ski racing technique and their relationship to performance."

Students:
Robert C. Reid
Tron Moger
Håvard Tjørhom
The Norwegian School of Sport Sciences

Advisors:
Gerald Smith
Per Haugen
The Norwegian School of Sport Sciences

Purpose:
This research is being completed in partial fulfillment of the requirements for a Ph.D. in biomechanics (Robert Reid) and two Master's theses (Tron Moger & Håvard Tjørhom) at the Norwegian School of Sport Sciences. The project is designed to examine the following general questions regarding turning technique in alpine ski racing:

- How do skiing line and degree of steering at the start of the turn relate to performance in varying course, terrain, and snow conditions?
- How does the degree of for / aft movement through a turn relate to performance in varying course, terrain, and snow conditions?
- How does the degree of up / down movement through a turn relate to performance in varying course, terrain, and snow conditions?

Methods:
To study these questions, we are planning – in conjunction with your coaching staff - a series of studies to be completed in varying terrain and course situations. These studies should not interfere with normal training. The main difference that you will notice is that there will be placed so-called "control points" on the hill surrounding the section of the course we intend to examine. These control points will be placed at a safe distance from the line and are constructed of safe materials (foam). We will film training from 4 to 5 different camera angles. The data generated from this filming can be used to reconstruct a 3-dimensional model of each skier's execution of the selected turns. This data can then be used to study our research questions. In addition to filming, we will need to measure various body segment lengths and circumferences in order to accurately calculate the center of gravity. This takes approximately 1 hour.

Confidentiality:
Participation in this study is confidential. Each athlete will be assigned a reference number that will be used in all references – both electronic and written - to the athlete's data. At the completion of the study, the list of reference numbers, names and data collection forms will be destroyed. However, since the video recordings of the athlete's skiing are an important part of the results, these will be saved. This study is registered with the Ombudsman for Privacy in Research, Norwegian Social Science Data Services AS.

Risks & Benefits to Participants:
Risks with participation in the study are minimal. The only additional risk beyond that experienced in normal training situations are the control points that are placed on the hill. However, these are not only constructed of safe materials but will also be placed at a safe distance from the line. In terms of benefits, these studies are being conducted in collaboration with your coaching staff. It is hoped that through these studies we will be able to deepen our understanding of the fundamental principles of turning technique and how these relate to performance. Additionally, each participating athlete will receive copies of resulting reports and access to data that may assist him in understanding technique. Finally, certain components of the information assimilated in this project may be useful in developing documents for the coach's education programs in the Norwegian ski federation.

Agreement:
I agree that Robert C. Reid, Håvard Tjørhom, and Tron Moger can use the information generated during my participation in the above-described projects for their Ph.D. Dissertation, Masters Theses and related publications. I understand that my participation in this project is confidential and that all information will be reported anonymously. I also understand that my participation in this project is voluntary and that I can withdraw myself from participation at any point without having to give a reason.

Participant Signature	**Date**	**Location**

Investigator	**Date**	**Location**

APPENDIX C. NSD Receipt

Norsk samfunnsvitenskapelig datatjeneste AS
NORWEGIAN SOCIAL SCIENCE DATA SERVICES

Harald Hårfagres gate 29
N-5007 Bergen
Norway
Tel: +47-55 58 21 17
Fax: +47-55 58 96 50
nsd@nsd.uib.no
www.nsd.uib.no
Org.nr: 985 321 884

Robert C. Reid
Seksjon for fysisk prestasjonsevne
Norges idrettshøgskole
Postboks 4014
0806 OSLO

Vår dato: 17.03.2006 Vår ref: 14368/SM Deres dato: Deres ref:

KVITTERING PÅ MELDING OM BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 13.02.2006. Meldingen gjelder prosjektet:

14368	*A study of the key aspects of modern alpine ski racing technique and their relationship to performance*
Behandlingsansvarlig	*Norges idrettshøgskole, ved institusjonens øverste leder*
Daglig ansvarlig	*Robert C. Reid*

Personvernombudet har vurdert prosjektet og finner at behandlingen av personopplysninger er meldepliktig i henhold til personopplysningsloven § 31. Behandlingen tilfredsstiller kravene i personopplysningsloven.

Personvernombudets vurdering forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldingen, korrespondanse med ombudet, eventuelle kommentarer samt personopplysningsloven/-helseregisterloven med forskrifter. Behandlingen av personopplysninger kan settes i gang.

Det gjøres oppmerksom på at det skal gis ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernombudets vurdering. Endringsmeldinger gis via et eget skjema, http://www.nsd.uib.no/personvern/endringsskjema. Det skal også gis melding etter tre år dersom prosjektet fortsatt pågår. Meldinger skal skje skriftlig til ombudet.

Personvernombudet har lagt ut opplysninger om prosjektet i en offentlig database, http://www.nsd.uib.no/personvern/register/

Personvernombudet vil ved prosjektets avslutning, 31.10.2008 rette en henvendelse angående status for behandlingen av personopplysninger.

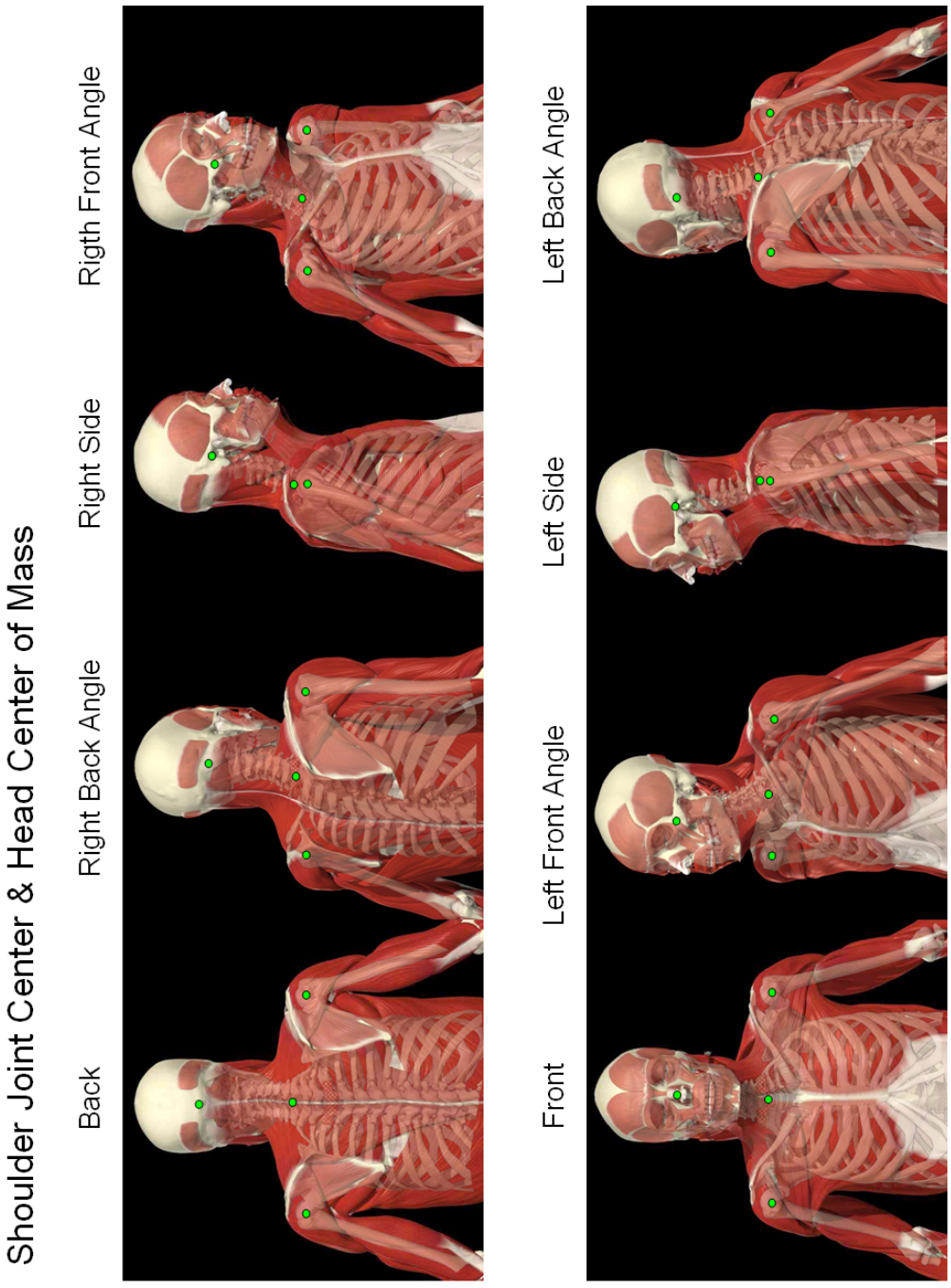
Vennlig hilsen

Vigdis Namtvedt Kvalheim Siv Midthassel

Kontaktperson: Siv Midthassel tlf: 55 58 83 34

Vedlegg: Prosjektvurdering

APPENDIX D. Digitization Photographs



(Images adapted from www.anatomy.tv)

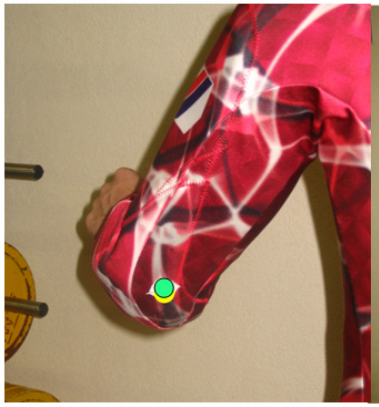
Shoulder Joint Center

Right Front | Right Front Angle | Right Side | Right Back Angle | Right Back

Left Back | Left Back Angle | Left Side | Left Front Angle | Left Front

Elbow Joint Center

Left Back



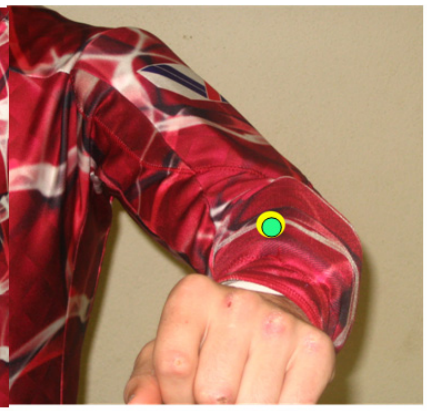
Back

Right Back

Right Front

Front

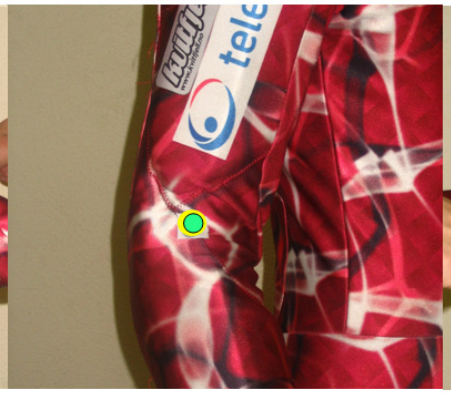
Left Front



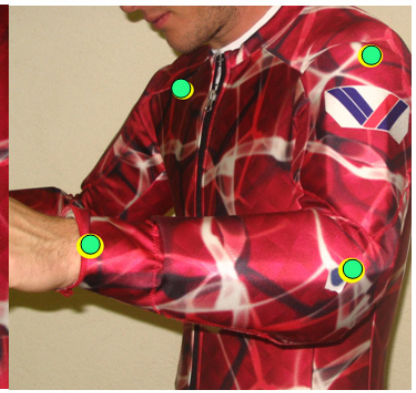
Elbow Joint Center

Right Side

Right Front Angle



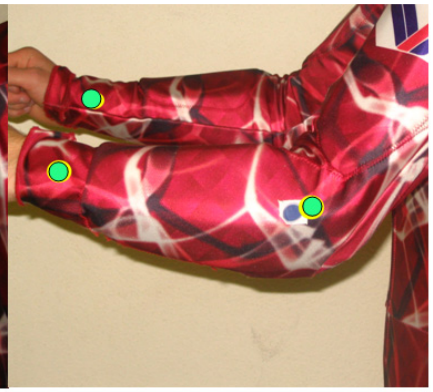
Left Front Angle



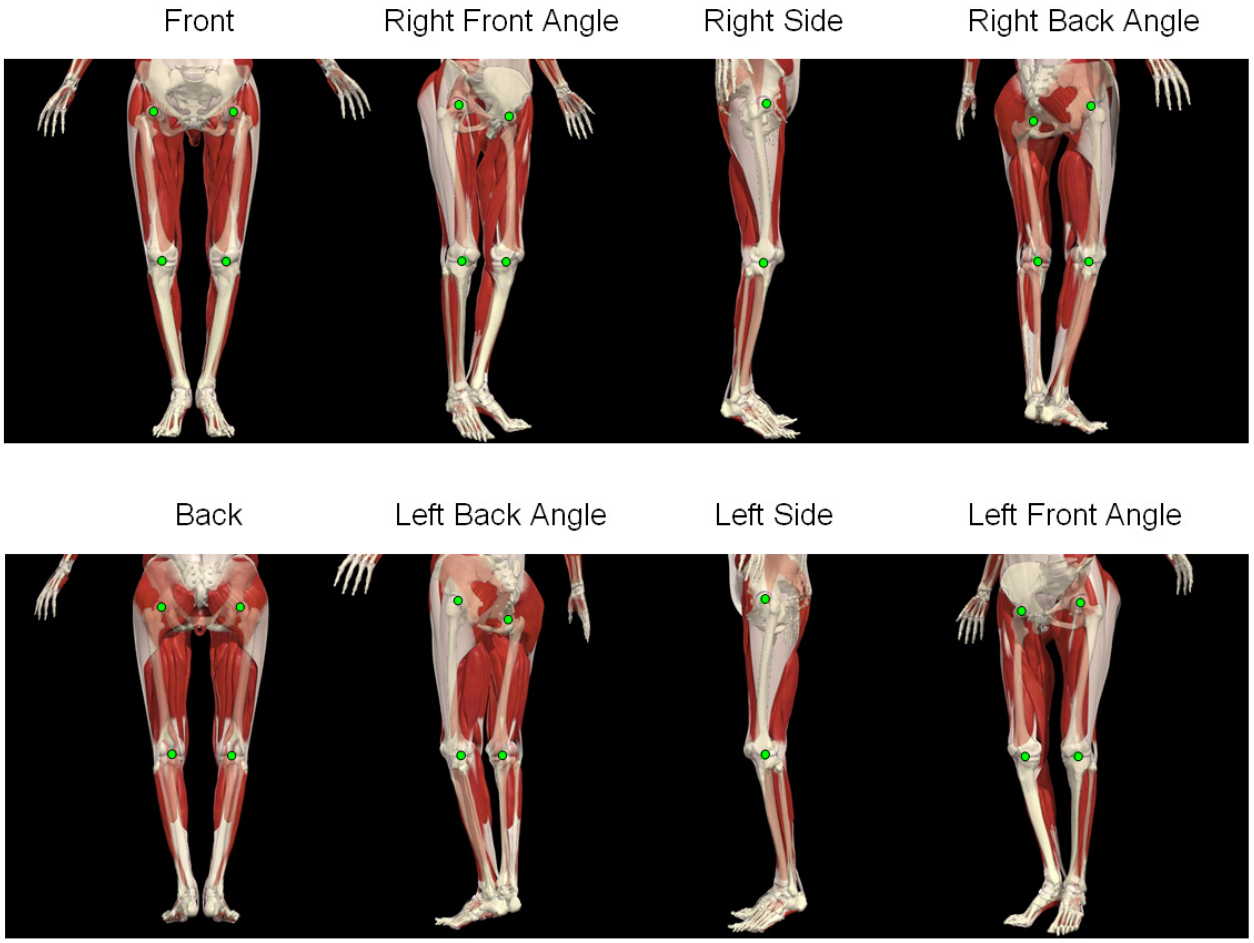
Right Side

Right Front

Left Side



Hip Joint Centers & Knee Joint Centers



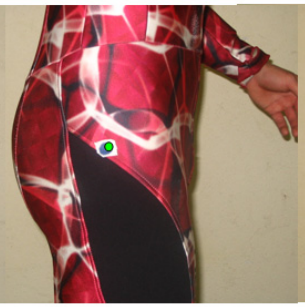
(Images adapted from www.anatomy.tv)

Hip Joint Center

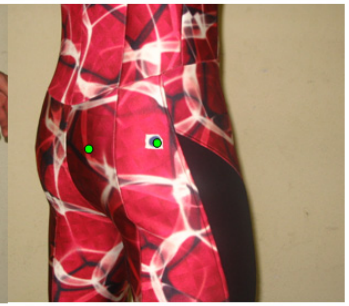
Front

Right Front Angle

Right Side



Right Back Angle

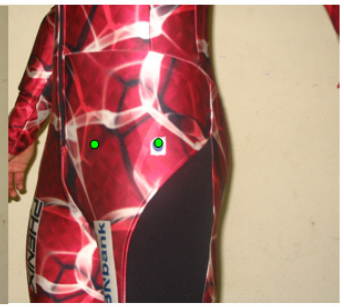


Back

Left Back Angle

Left Side

Left Front Angle



Hip Joint Center

Front

Left Front Angle

Left Side

Left Back Angle

Back

Knee Joint Center

Left Front | Left Front Angle | Left Side | Left Back Angle | Left Back

Right Back | Right Back Angle | Right Side | Right Front Angle | Right Front

APPENDIX E. Challis Algorithm Output

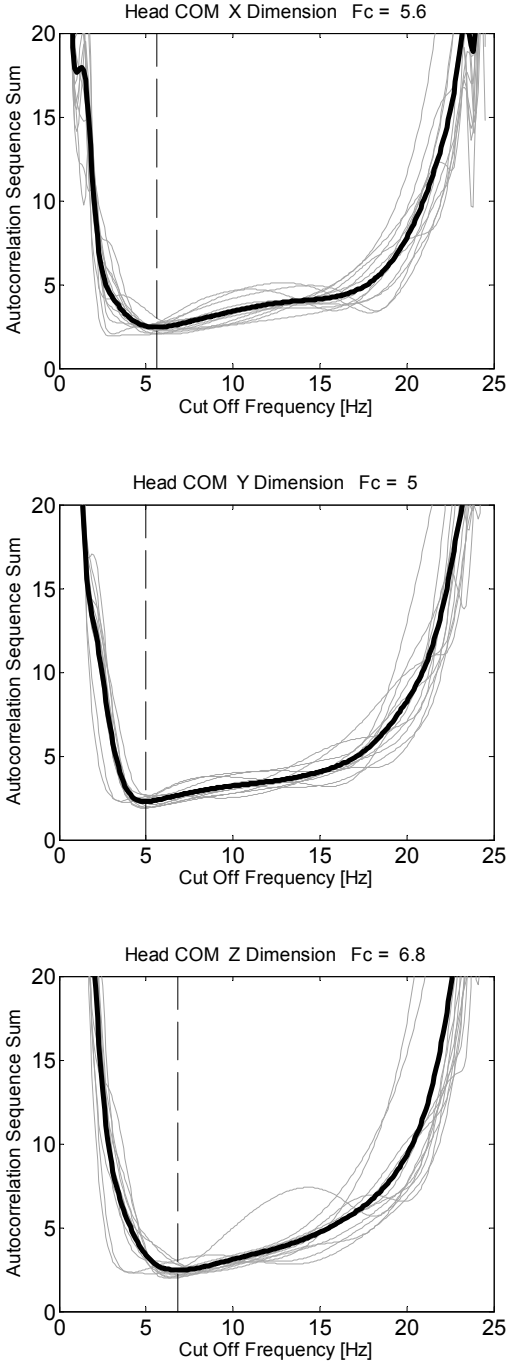


Figure E.1. Challis algorithm output for $\vec{P}_{\mathrm{HEAD}}(\mathrm{t})$ in the Course Coordinate System X'-, Y'-, and Z'- dimensions. Gray lines are each individual trial and the dark line is the ensemble average.

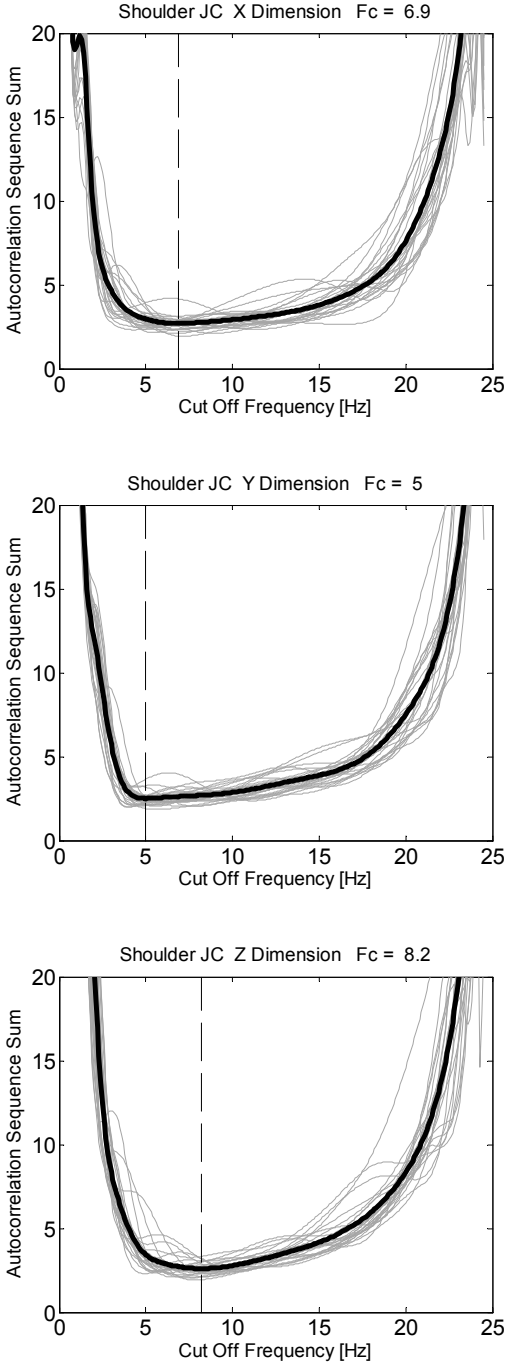


Figure E.2. Challis algorithm output for $\vec{P}_{\mathrm{SJC}}(\mathrm{t})$ in the Course Coordinate System X'-, Y'-, and Z'- dimensions. Gray lines are each individual trial and the dark line is the ensemble average.

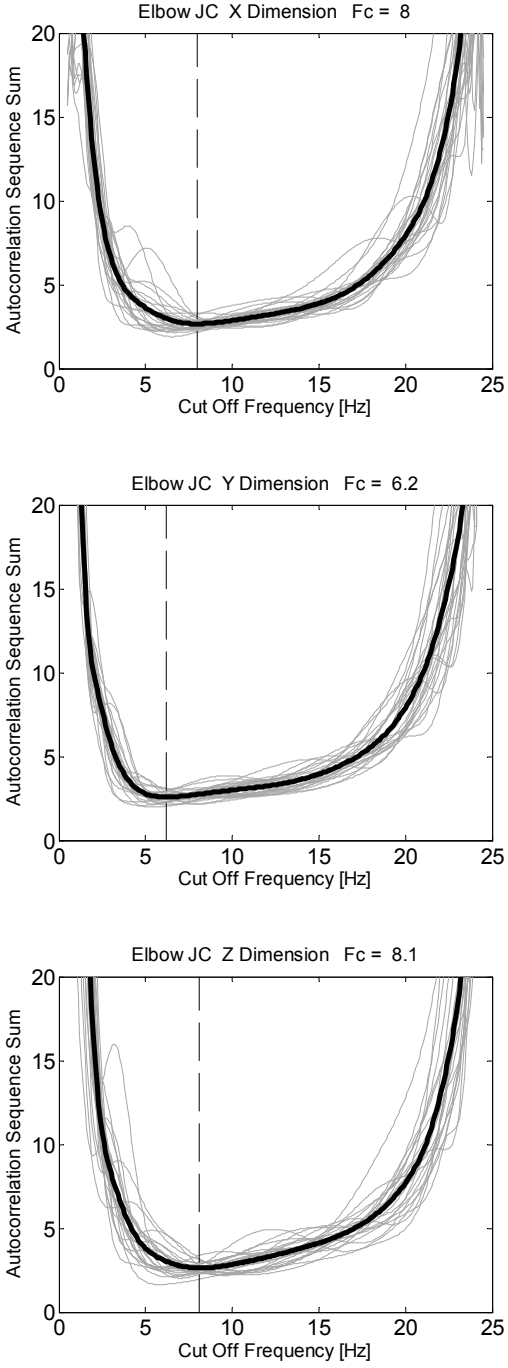


Figure E.3. Challis algorithm output for $\vec{P}_{\mathrm{EJC}}(\mathrm{t})$ in the Course Coordinate System X'-, Y'-, and Z'- dimensions. Gray lines are each individual trial and the dark line is the ensemble average.

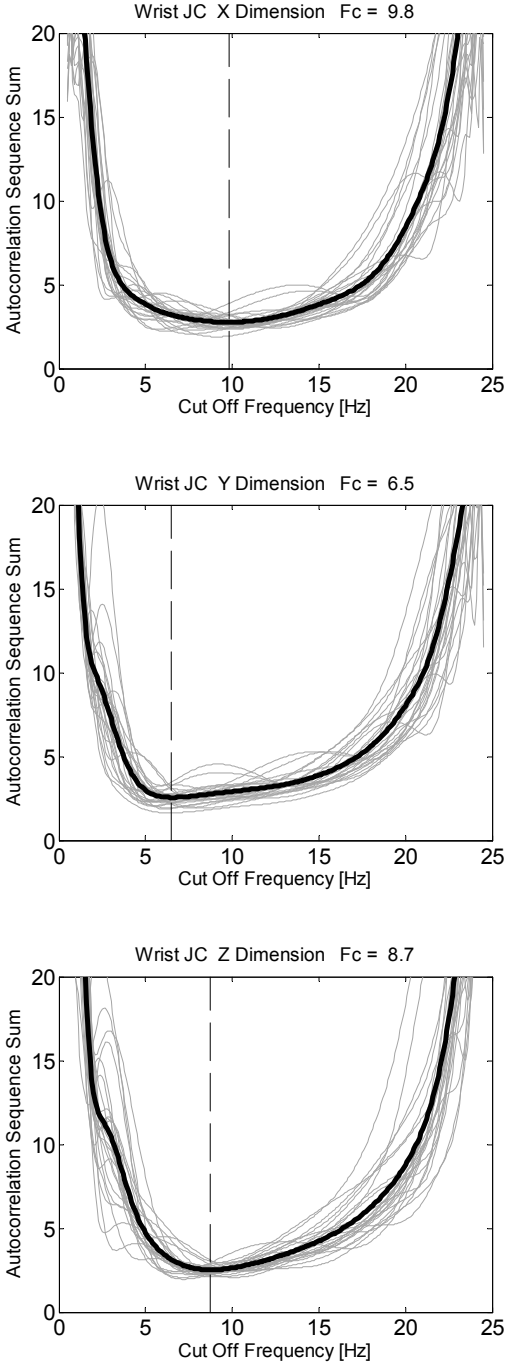


Figure E.4. Challis algorithm output for $\vec{P}_{\mathrm{WJC}}(\mathrm{t})$ in the Course Coordinate System X'-, Y'-, and Z'- dimensions. Gray lines are each individual trial and the dark line is the ensemble average.

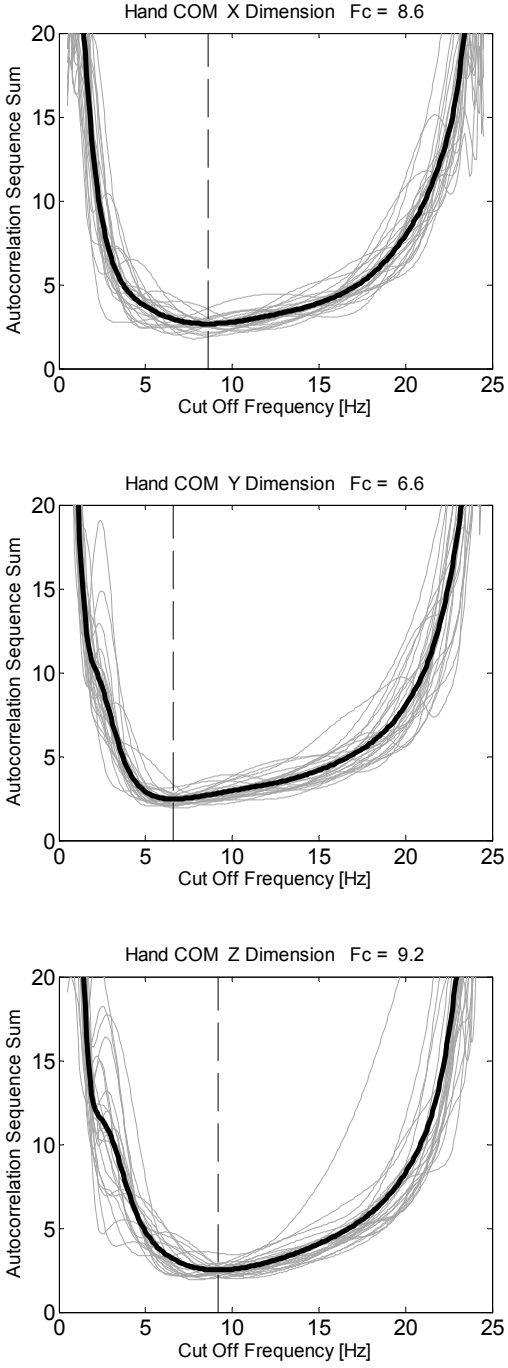


Figure E.5. Challis algorithm output for $\vec{P}_{\mathrm{HCOM}}(\mathrm{t})$ in the Course Coordinate System X'-, Y'-, and Z'- dimensions. Gray lines are each individual trial and the dark line is the ensemble average.

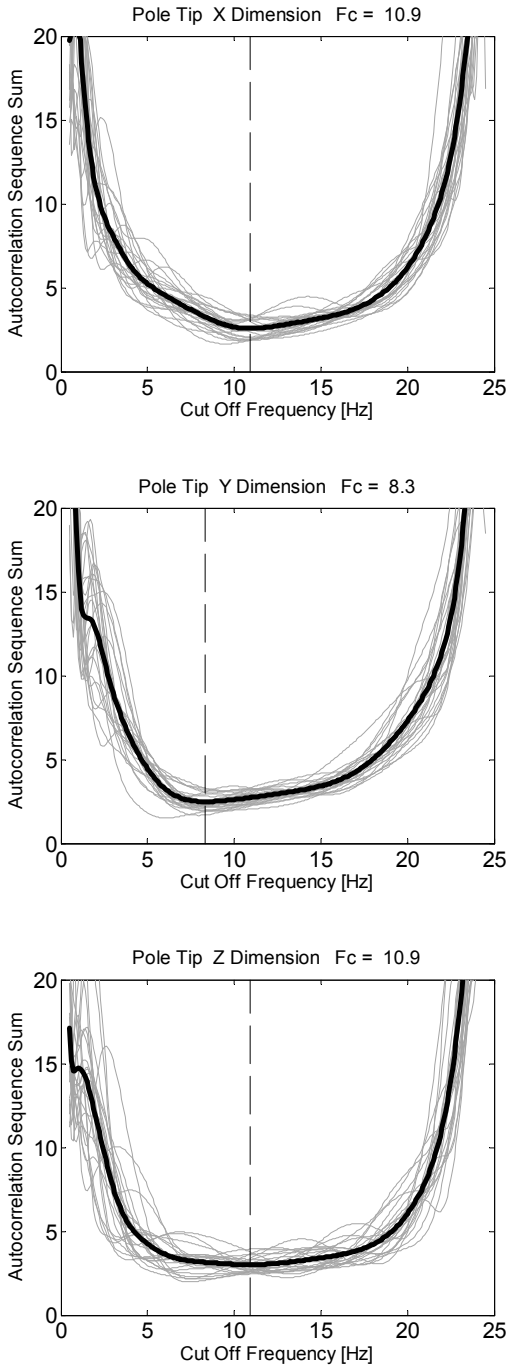


Figure E.6. Challis algorithm output for $\vec{P}_{\mathrm{POLE}}(\mathrm{t})$ in the Course Coordinate System X'-, Y'-, and Z'- dimensions. Gray lines are each individual trial and the dark line is the ensemble average.

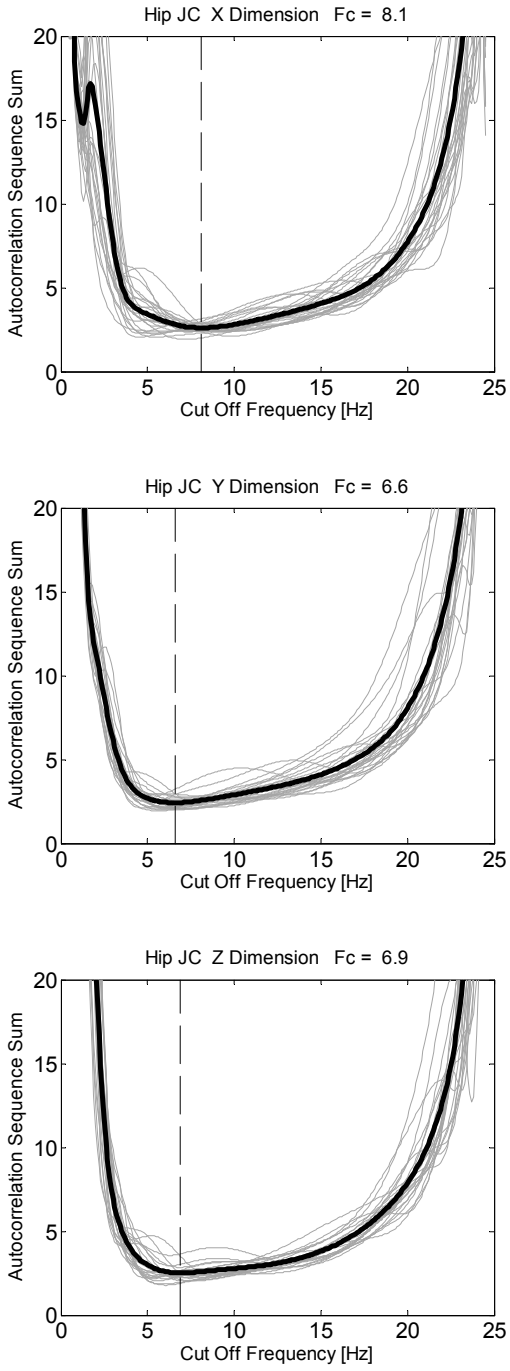


Figure E.7. Challis algorithm output for $\vec{P}_{\mathrm{HJC}}(\mathrm{t})$ in the Course Coordinate System X'-, Y'-, and Z'- dimensions. Gray lines are each individual trial and the dark line is the ensemble average.

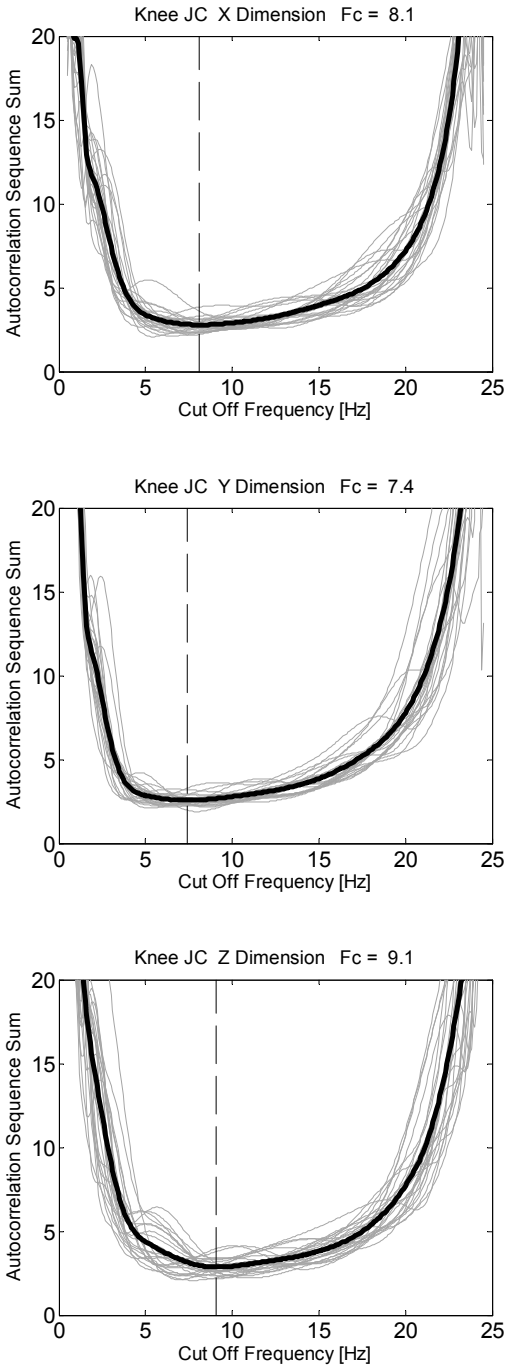


Figure E.8. Challis algorithm output for $\vec{P}_{\mathrm{KJC}}(\mathrm{t})$ in the Course Coordinate System X'-, Y'-, and Z'- dimensions. Gray lines are each individual trial and the dark line is the ensemble average.

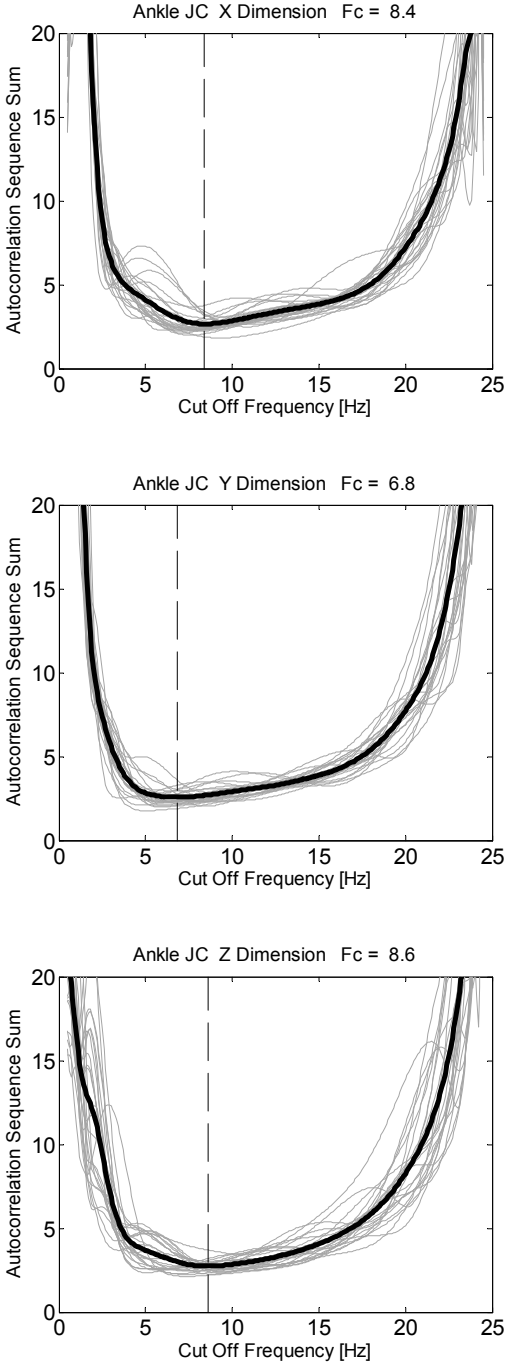


Figure E.9. Challis algorithm output for $\vec{P}_{\mathrm{AJC}}(\mathrm{t})$ in the Course Coordinate System X'-, Y'-, and Z'- dimensions. Gray lines are each individual trial and the dark line is the ensemble average.

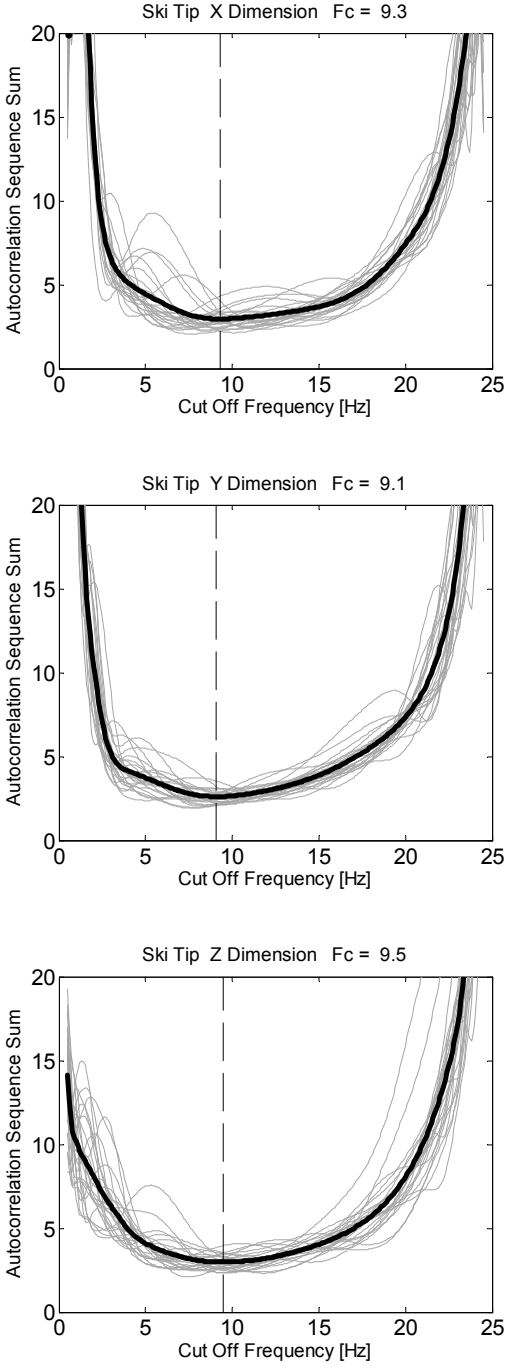


Figure E.10. Challis algorithm output for $\vec{P}_{\mathrm{TIP}}(\mathrm{t})$ in the Course Coordinate System X'-, Y'-, and Z'- dimensions. Gray lines are each individual trial and the dark line is the ensemble average.

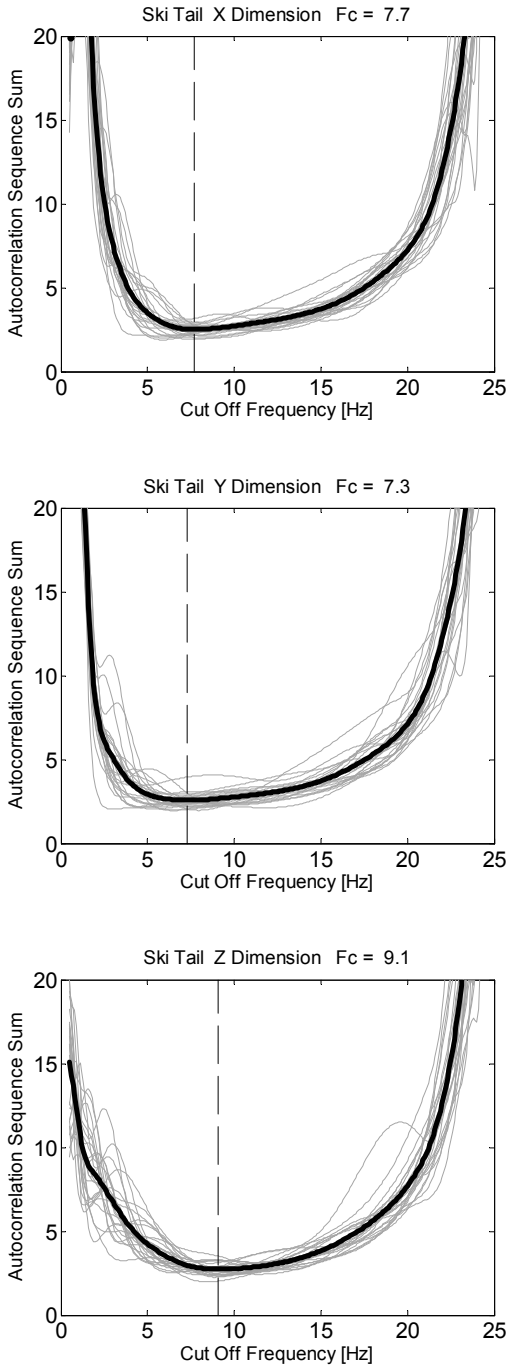


Figure E.11. Challis algorithm output for $\vec{P}_{\mathrm{TAIL}}(\mathrm{t})$ in the Course Coordinate System X'-, Y'-, and Z'- dimensions. Gray lines are each individual trial and the dark line is the ensemble average.

APPENDIX F. Control Point Maps

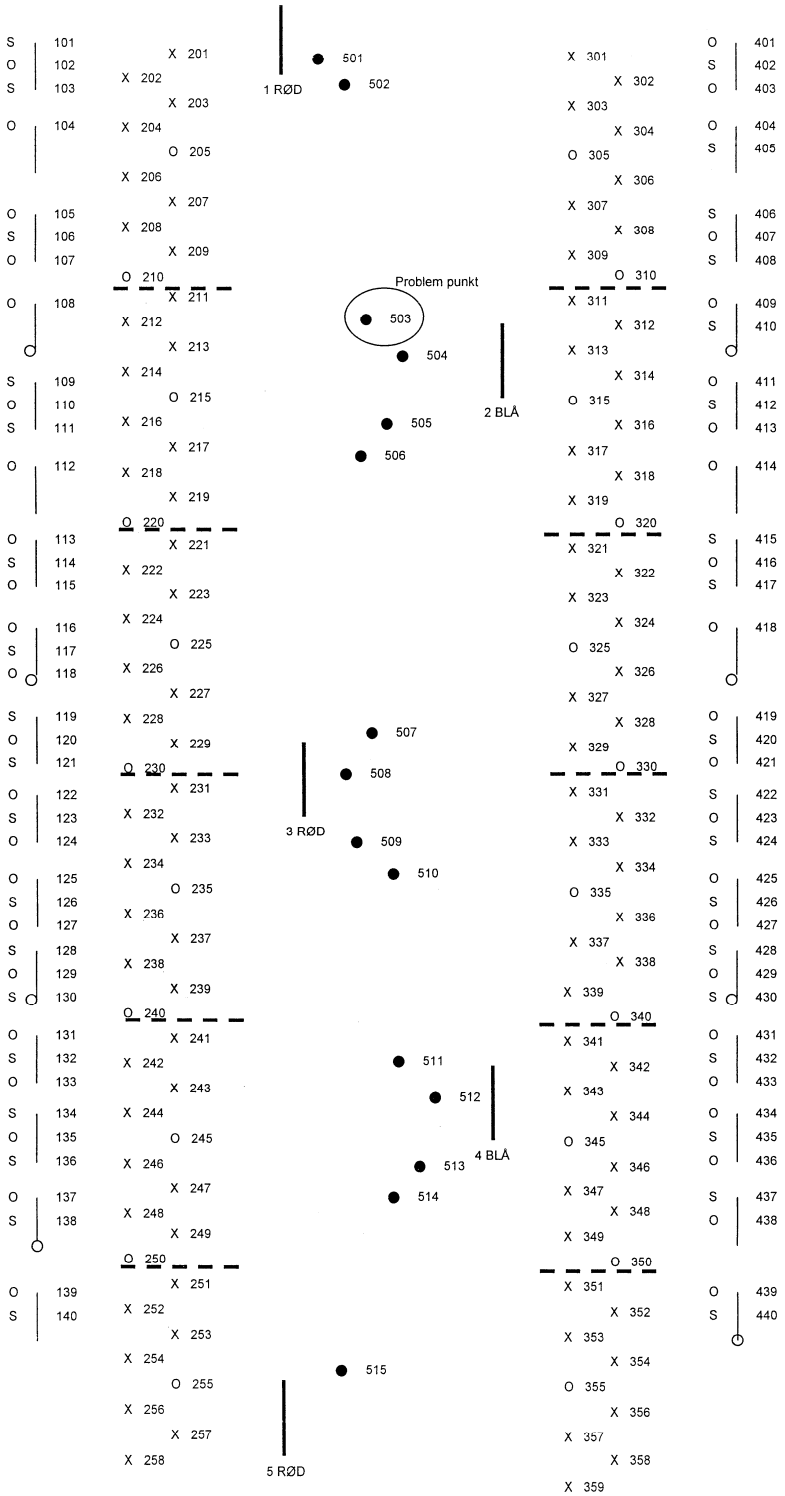


Figure F.1. Control point map of the 13 m course.

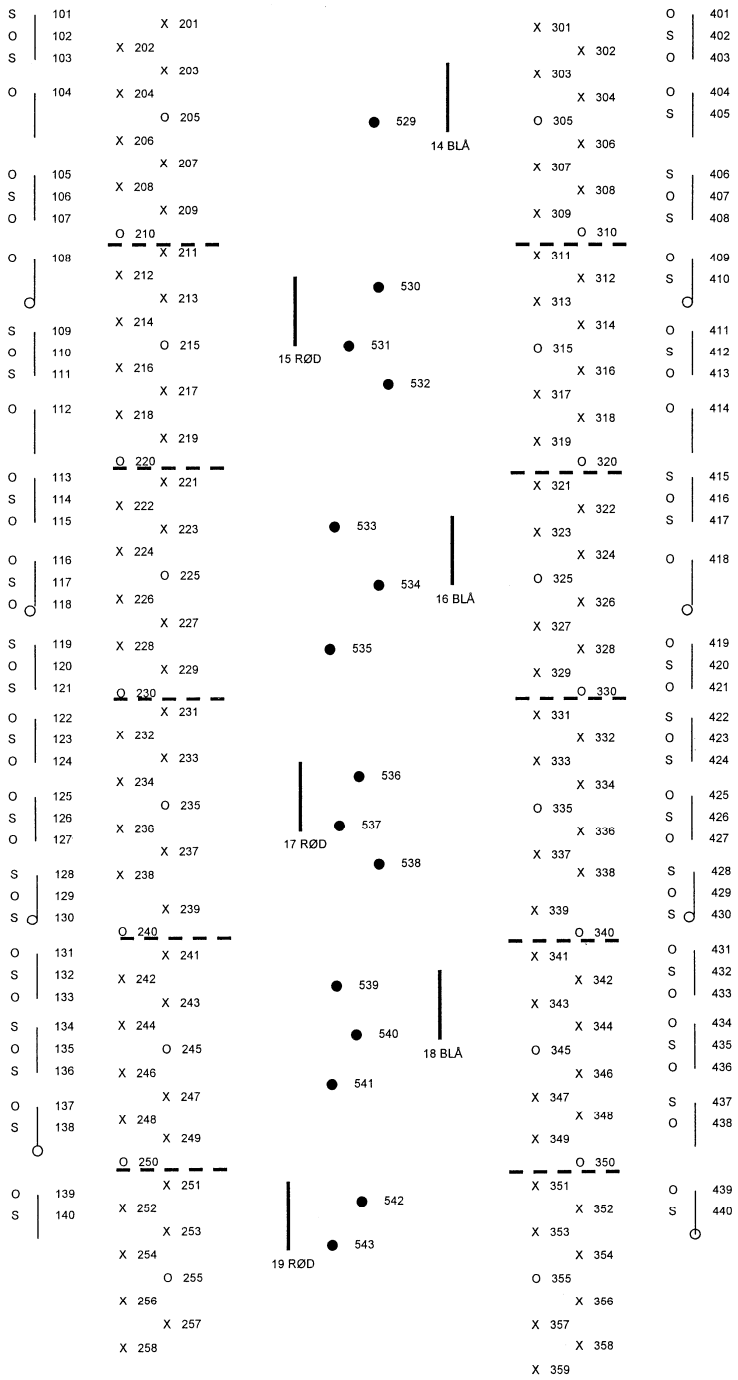


Figure F.2. Control point map of the 10 m course.

APPENDIX G: Descriptive Statistics

TABLE G.1. Center of mass speed descriptive statistics. Values are means ± standard deviations (n = 6).

		10 m Course	13 m Course
Turn Cycle Descriptives			
Turn Start	[$m \cdot s^{-1}$]	11.91 ± 0.27	13.48 ± 0.33
Initiation Phase Mean	[$m \cdot s^{-1}$]	12.25 ± 0.27	13.86 ± 0.34
Turn Phase 1 Mean	[$m \cdot s^{-1}$]	12.41 ± 0.25	14.12 ± 0.33
Gate Passage	[$m \cdot s^{-1}$]	12.06 ± 0.34	13.91 ± 0.33
Turn Phase 2 Mean	[$m \cdot s^{-1}$]	11.86 ± 0.38	13.68 ± 0.33
Completion Phase Mean	[$m \cdot s^{-1}$]	11.91 ± 0.37	13.52 ± 0.33
Turn End	[$m \cdot s^{-1}$]	12.13 ± 0.36	13.62 ± 0.34
Key Variable Descriptives			
Mean Speed	[$m \cdot s^{-1}$]	12.12 ± 0.29	13.83 ± 0.32
Maximum Speed	[$m \cdot s^{-1}$]	12.62 ± 0.24	14.24 ± 0.35
Maximum Time Point	[%]	32.9 ± 3.5	37.1 ± 6.6
Minimum Speed	[$m \cdot s^{-1}$]	11.74 ± 0.36	13.46 ± 0.31
Minimum Time Point	[%]	73.33 ± 3.74	88.83 ± 2.48
Peak-to-Peak Amplitude	[$m \cdot s^{-1}$]	0.98 ± 0.13	0.87 ± 0.09

TABLE G.2. Outside ski mid point speed descriptive statistics. Values are means ± standard deviations (n = 6).

		10 m Course	13 m Course
Turn Cycle Descriptives			
Turn Start	[$m \cdot s^{-1}$]	11.76 ± 0.34	13.19 ± 0.24
Initiation Phase Mean	[$m \cdot s^{-1}$]	12.47 ± 0.38	13.98 ± 0.40
Turn Phase 1 Mean	[$m \cdot s^{-1}$]	13.48 ± 0.30	15.38 ± 0.53
Gate Passage	[$m \cdot s^{-1}$]	13.67 ± 0.53	15.50 ± 0.70
Turn Phase 2 Mean	[$m \cdot s^{-1}$]	13.62 ± 0.58	15.54 ± 0.54
Completion Phase Mean	[$m \cdot s^{-1}$]	12.49 ± 0.45	14.45 ± 0.16
Turn End	[$m \cdot s^{-1}$]	12.07 ± 0.28	13.51 ± 0.30
Key Variable Descriptives			
Mean Speed	[$m \cdot s^{-1}$]	12.98 ± 0.30	14.76 ± 0.28
Maximum Speed	[$m \cdot s^{-1}$]	14.15 ± 0.49	16.10 ± 0.36
Maximum Time Point	[%]	48.8 ± 8.9	71.3 ± 11.0
Minimum Speed	[$m \cdot s^{-1}$]	11.61 ± 0.30	13.10 ± 0.15
Minimum Time Point		Transition	Transition
Peak-to-Peak Amplitude	[$m \cdot s^{-1}$]	2.54 ± 0.39	3.00 ± 0.38

TABLE G.3. Center of mass and outside ski turn radius descriptive statistics. Values are means ± standard deviations (n = 6).

		10 m Course	13 m Course
Center of Mass			
Turn Cycle Descriptives			
Turn Phase Mean	[m]	8.75 ± 0.36	9.93 ± 0.45
Key Variable Descriptives			
Minimum Turn Radius	[m]	5.43 ± 0.33	6.48 ± 0.36
Minimum Time Point	[%]	53.3 ± 6.6	63.8 ± 5.9
Outside Ski			
Turn Cycle Descriptives			
Turn Phase Mean	[m]	7.14 ± 0.37	10.58 ± 3.03
Key Variable Descriptives			
Minimum Turn Radius	[m]	3.96 ± 0.23	4.94 ± 0.59
Minimum Time Point	[%]	57.7 ± 6.7	69.4 ± 4.7

TABLE G.4. Center of mass attack angle descriptive statistics. Values are means ± standard deviations (n = 6).

		10 m Course	13 m Course
Turn Cycle Descriptives			
Turn Start	[deg]	–10.9 ± 2.4	–12.9 ± 2.8
Initiation Phase Mean	[deg]	–3.1 ± 4.2	–2.6 ± 3.6
Turn Phase 1 Mean	[deg]	9.7 ± 4.9	6.2 ± 3.5
Gate Passage	[deg]	7.5 ± 3.2	5.3 ± 1.8
Turn Phase 2 Mean	[deg]	7.9 ± 1.3	7.3 ± 1.0
Completion Phase Mean	[deg]	13.5 ± 1.4	15.0 ± 2.0
Turn End	[deg]	13.9 ± 2.3	15.9 ± 2.1
Key Variable Descriptives			
Zero Time Point	[%]	21.4 ± 7.1	23.2 ± 8.4
Initial Maximum	[deg]	15.3 ± 5.2 *	10.6 ± 6.0 *
Initial Maximum Time Point	[%]	38.4 ± 4.5 *	34.1 ± 6.9 *
Secondary Maximum	[deg]	16.2 ± 1.3	17.5 ± 2.3
Secondary Maximum Time Point	[%]	93.1 ± 3.5	95.4 ± 2.2

* Only turns that demonstrated an initial maximum are included (n = 9 on both courses).

TABLE G.5. Outside ski edge angle descriptive statistics. Values are means ± standard deviations (n = 6).

		10 m Course	13 m Course
Turn Cycle Descriptives			
Turn Start	[deg]	5.1 ± 4.6	4.5 ± 5.1
Initiation Phase Mean	[deg]	31.7 ± 3.5	38.2 ± 3.4
Turn Phase 1 Mean	[deg]	59.2 ± 1.6	64.4 ± 1.4
Gate Passage	[deg]	64.6 ± 1.5	70.2 ± 1.3
Turn Phase 2 Mean	[deg]	61.9 ± 3.3	66.1 ± 2.0
Completion Phase Mean	[deg]	32.2 ± 3.4	33.2 ± 3.1
Turn End	[deg]	4.7 ± 4.4	6.3 ± 5.5
Key Variable Descriptives			
Maximum Edge Angle	[deg]	65.7 ± 1.7	71.0 ± 1.9
Maximum Time Point	[%]	58.0 ± 4.1	61.6 ± 3.3

TABLE G.6. Outside ski attack angle descriptive statistics. Values are means ± standard deviations (n = 6).

		10 m Course	13 m Course
Turn Cycle Descriptives			
Turn Start	[deg]	3.1 ± 2.4	0.5 ± 2.4
Initiation Phase Mean	[deg]	7.4 ± 4.3	6.0 ± 3.8
Turn Phase 1 Mean	[deg]	11.7 ± 4.5	6.7 ± 3.4
Gate Passage	[deg]	6.8 ± 3.6	5.7 ± 2.2
Turn Phase 2 Mean	[deg]	3.7 ± 1.6	3.9 ± 1.1
Completion Phase Mean	[deg]	1.3 ± 1.3	2.4 ± 0.5
Turn End	[deg]	–1.9 ± 2.3	1.5 ± 1.6
Key Variable Descriptives			
Maximum Attack Angle	[deg]	15.1 ± 5.3	12.1 ± 4.9
Maximum Time Point	[%]	36.3 ± 5.4	39.9 ± 12.6

TABLE G.7. Center of mass inclination angle descriptive statistics. Values are means ± standard deviations (n = 6).

		10 m Course	13 m Course
Turn Cycle Descriptives			
Turn Start	[deg]	0.4 ± 0.6	0.1 ± 0.8
Initiation Phase Mean	[deg]	22.2 ± 2.3	28.5 ± 2.8
Turn Phase 1 Mean	[deg]	46.4 ± 1.2	52.0 ± 2.2
Gate Passage	[deg]	49.0 ± 1.2	55.8 ± 1.6
Turn Phase 2 Mean	[deg]	43.9 ± 2.5	49.4 ± 1.4
Completion Phase Mean	[deg]	20.0 ± 1.9	20.0 ± 1.1
Turn End	[deg]	0.5 ± 0.8	1.1 ± 0.6
Key Variable Descriptives			
Maximum Inclination	[deg]	49.9 ± 1.0	56.2 ± 1.5
Maximum Time Point	[%]	49.8 ± 2.4	57.5 ± 1.5

TABLE G.8. Hip angulation descriptive statistics. Values are means ± standard deviations (n = 6).

		10 m Course	13 m Course
Turn Cycle Descriptives			
Turn Start	[deg]	0.7 ± 2.0	1.3 ± 3.7
Initiation Phase Mean	[deg]	5.8 ± 1.7	7.3 ± 2.1
Turn Phase 1 Mean	[deg]	8.7 ± 1.2	8.3 ± 1.0
Gate Passage	[deg]	10.7 ± 1.2	9.0 ± 1.6
Turn Phase 2 Mean	[deg]	13.2 ± 1.2	12.6 ± 2.0
Completion Phase Mean	[deg]	15.8 ± 1.6	19.7 ± 5.2
Turn End	[deg]	13.7 ± 2.4	16.9 ± 5.8
Key Variable Descriptives			
Maximum Angulation	[deg]	17.1 ± 1.9	21.6 ± 5.6
Maximum Time Point	[%]	88.8 ± 4.4	91.3 ± 2.2

TABLE G.9. Knee angulation descriptive statistics. Values are means ± standard deviations (n = 6).

		10 m Course	13 m Course
Turn Cycle Descriptives			
Turn Start	[deg]	4.0 ± 3.3	3.1 ± 1.9
Initiation Phase Mean	[deg]	3.7 ± 3.0	2.5 ± 1.3
Turn Phase 1 Mean	[deg]	4.1 ± 1.9	4.2 ± 1.8
Gate Passage	[deg]	4.9 ± 1.1	5.4 ± 1.2
Turn Phase 2 Mean	[deg]	4.8 ± 1.6	4.1 ± 0.9
Completion Phase Mean	[deg]	–3.6 ± 2.9	–6.5 ± 3.5
Turn End	[deg]	–9.6 ± 4.1	–11.7 ± 2.1
Key Variable Descriptives			
Maximum Angulation	[deg]	7.5 ± 1.9	6.7 ± 0.8
Maximum Time Point	[%]	42.5 ± 11.0	62.9 ± 6.9

TABLE G.10. Center of mass position orthogonal to the snow surface (Z′ in the Course Coordinate System X′Y′Z′ reference system) descriptive statistics. Values are means ± standard deviations (n = 6).

		10 m Course	13 m Course
Turn Cycle Descriptives			
Turn Start	[cm]	70.7 ± 3.0	67.7 ± 3.8
Initiation Phase Mean	[cm]	66.3 ± 3.0	65.4 ± 4.3
Turn Phase 1 Mean	[cm]	48.0 ± 1.8	45.2 ± 2.8
Gate Passage	[cm]	43.0 ± 1.7	39.6 ± 2.0
Turn Phase 2 Mean	[cm]	46.5 ± 1.8	42.1 ± 2.1
Completion Phase Mean	[cm]	62.2 ± 2.2	59.2 ± 2.5
Turn End	[cm]	68.1 ± 2.8	66.7 ± 2.9
Key Variable Descriptives			
Maximum Position	[cm]	70.9 ± 3.0	70.2 ± 3.9
Maximum Time Point	[%]	1.6 ± 2.5	8.1 ± 1.6
Minimum Position	[cm]	42.5 ± 1.9	38.7 ± 1.9
Minimum Time Point	[%]	53.8 ± 2.3	62.7 ± 1.7
Mean Position	[cm]	56.1 ± 2.2	53.7 ± 2.9
Peak-to-Peak Amplitude	[cm]	27.2 ± 1.6	31.0 ± 1.6

TABLE G.11. Center of mass to outside ankle joint center distance descriptive statistics. Values are means ± standard deviations (n = 6).

		10 m Course	13 m Course
Turn Cycle Descriptives			
Turn Start	[cm]	61.5 ± 3.8	55.8 ± 4.0
Initiation Phase Mean	[cm]	68.6 ± 2.6	71.8 ± 2.8
Turn Phase 1 Mean	[cm]	76.1 ± 2.9	78.1 ± 2.6
Gate Passage	[cm]	75.5 ± 3.4	75.6 ± 3.5
Turn Phase 2 Mean	[cm]	72.0 ± 1.9	74.3 ± 3.1
Completion Phase Mean	[cm]	63.0 ± 2.5	60.6 ± 4.7
Turn End	[cm]	57.4 ± 3.0	55.7 ± 4.0
Key Variable Descriptives			
Maximum Distance	[cm]	77.8 ± 2.4	82.6 ± 2.8
Maximum Time Point	[%]	39.3 ± 8.9	34.9 ± 8.5
Mean	[cm]	69.9 ± 1.9	72.1 ± 2.3
ROM	[cm]	20.7 ± 3.2	28.7 ± 4.3

TABLE G.12. Center of mass fore/aft position descriptive statistics. Values are means ± standard deviations (n = 6).

		10 m Course	13 m Course
Turn Cycle Descriptives			
Turn Start	[cm]	–11.4 ± 4.4	–13.8 ± 4.3
Initiation Phase Mean	[cm]	–5.1 ± 2.7	–4.8 ± 1.4
Turn Phase 1 Mean	[cm]	11.8 ± 5.0	8.7 ± 3.7
Gate Passage	[cm]	11.2 ± 4.0	6.2 ± 3.4
Turn Phase 2 Mean	[cm]	7.6 ± 2.9	7.5 ± 4.4
Completion Phase Mean	[cm]	–3.8 ± 3.6	–5.4 ± 4.0
Turn End	[cm]	–7.8 ± 4.0	–10.7 ± 3.0
Key Variable Descriptives			
Maximum Position	[cm]	16.4 ± 4.1	14.5 ± 3.1
Maximum Time Point	[%]	47.8 ± 7.7	50.3 ± 14.0
Minimum Position	[cm]	–13.4 ± 3.6	–15.2 ± 3.7
Minimum Time Point		Transition	Transition
Mean Position	[cm]	2.5 ± 2.5	1.6 ± 2.8
Range of Motion	[cm]	26.0 ± 6.3	26.7 ± 0.4

TABLE G.13. Air drag force descriptive statistics. Values are means ± standard deviations (n = 6).

		10 m Course	13 m Course
Turn Cycle Descriptives			
Turn Start	[N]	49 ± 3	58 ± 7
Initiation Phase Mean	[N]	54 ± 3	73 ± 8
Turn Phase 1 Mean	[N]	58 ± 3	73 ± 5
Gate Passage	[N]	51 ± 3	66 ± 6
Turn Phase 2 Mean	[N]	49 ± 2	65 ± 6
Completion Phase Mean	[N]	48 ± 3	58 ± 7
Turn End	[N]	48 ± 2	59 ± 7
Key Variable Descriptives			
Maximum Force	[N]	62 ± 3	85 ± 8
Maximum Time Point	[%]	31.5 ± 3.3	27.0 ± 1.4
Minimum Force	[N]	44 ± 3	55 ± 7
Mean Force	[N]	52 ± 1	69 ± 7

TABLE G.14. Air drag force power descriptive statistics. Values are means ± standard deviations (n = 6).

		10 m Course	13 m Course
Turn Cycle Descriptives			
Turn Start	[W]	–578 ± 38	–780 ± 113
Initiation Phase Mean	[W]	–668 ± 30	–1017 ± 137
Turn Phase 1 Mean	[W]	–717 ± 33	–1032 ± 94
Gate Passage	[W]	–621 ± 40	–925 ± 99
Turn Phase 2 Mean	[W]	–584 ± 45	–888 ± 106
Completion Phase Mean	[W]	–572 ± 41	–785 ± 115
Turn End	[W]	–580 ± 37	–803 ± 118
Key Variable Descriptives			
Maximum Power	[W]	–526 ± 41	–742 ± 107
Maximum Time Point	[%]	54.1 ± 19.1	45.6 ± 1.2
Minimum Power	[W]	–779 ± 39	–1197 ± 137
Minimum Time Point	[%]	32.1 ± 2.5	28.1 ± 1.8
Mean Power	[W]	–638 ± 18	–954 ± 113

TABLE G.15. Snow reaction force descriptive statistics. Values are means ± standard deviations (n = 6).

		10 m Course	13 m Course
Turn Cycle Descriptives			
Turn Start	[N] / [BW]	256 ± 49 /	206 ± 76 /
Initiation Phase Mean	[N] / [BW]	498 ± 48 / 0.52 ± 0.05	526 ± 87 / 0.55 ± 0.11
Turn Phase 1 Mean	[N] / [BW]	2431 ± 128 / 2.54 ± 0.12	2361 ± 296 / 2.46 ± 0.27
Gate Passage	[N] / [BW]	2898 ± 433 /	2860 ± 409 /
Turn Phase 2 Mean	[N] / [BW]	2485 ± 287 / 2.59 ± 0.20	2865 ± 270 / 2.99 ± 0.14
Completion Phase Mean	[N] / [BW]	622 ± 63 / 0.65 ± 0.09	729 ± 100 / 0.76 ± 0.08
Turn End	[N] / [BW]	193 ± 76 /	230 ± 51 /
Key Variable Descriptives			
Maximum Force	[N] / [BW]	3212 ± 329 / 3.35 ± 0.20	3378 ± 251 / 3.53 ± 0.16
Maximum Time Point	[%]	50.9 ± 5.9	66.6 ± 4.2
Minimum Force	[N] / [BW]	158 ± 52 / 0.17 ± 0.06	85 ± 45 / 0.09 ± 0.05
Minimum Time Point	[%]	0.8 ± 6.3	6.5 ± 3.7
Mean Force	[N] / [BW]	1494 ± 128 / 1.56 ± 0.05	1600 ± 147 / 1.67 ± 0.05

TABLE G.16. Snow reaction force power descriptive statistics. Values are means ± standard deviations (n = 6).

		10 m Course	13 m Course
Turn Cycle Descriptives			
Turn Start	[W]	258 ± 539	–235 ± 448
Initiation Phase Mean	[W]	–442 ± 238	–810 ± 474
Turn Phase 1 Mean	[W]	–7190 ± 1356	–5915 ± 735
Gate Passage	[W]	–8679 ± 1611	–8580 ± 1989
Turn Phase 2 Mean	[W]	–4455 ± 752	–5802 ± 786
Completion Phase Mean	[W]	–596 ± 274	–1789 ± 423
Turn End	[W]	339 ± 904	–158 ± 889
Key Variable Descriptives			
Maximum Power	[W]	1123 ± 254	1312 ± 557
Maximum Time Point	[%]	2.5 ± 5.5	3.2 ± 9.7
Minimum Power	[W]	–10246 ± 1027	–9774 ± 1718
Minimum Time Point	[%]	47.2 ± 4.4	56.8 ± 4.5
Mean Power	[W]	–3104 ± 397	–3430 ± 330

TABLE G.17. Vertical component of the snow reaction force descriptive statistics. Values are means ± standard deviations (n = 6).

		10 m Course	13 m Course
Turn Cycle Descriptives			
Turn Start	[N]	226 ± 57	124 ± 81
Initiation Phase Mean	[N]	385 ± 51	365 ± 61
Turn Phase 1 Mean	[N]	1429 ± 86	1272 ± 160
Gate Passage	[N]	1647 ± 190	1394 ± 169
Turn Phase 2 Mean	[N]	1476 ± 144	1533 ± 117
Completion Phase Mean	[N]	499 ± 54	552 ± 101
Turn End	[N]	145 ± 79	168 ± 69
Key Variable Descriptives			
Maximum Force	[N]	1832 ± 207	1716 ± 139
Maximum Time Point	[%]	52.8 ± 4.2	67.3 ± 6.6
Minimum Force	[N]	130 ± 51	50 ± 50
Minimum Time Point	[%]	0.8 ± 5.7	6.3 ± 3.5
Mean Force	[N]	937 ± 69	916 ± 77

TABLE G.18. Gravitational force power descriptive statistics. Values are means ± standard deviations (n = 6).

		10 m Course	13 m Course
Turn Cycle Descriptives			
Turn Start	[W]	3731 ± 190	3739 ± 326
Initiation Phase Mean	[W]	4502 ± 231	4842 ± 383
Turn Phase 1 Mean	[W]	4871 ± 401	5393 ± 415
Gate Passage	[W]	4284 ± 454	5004 ± 400
Turn Phase 2 Mean	[W]	3546 ± 286	4177 ± 331
Completion Phase Mean	[W]	3176 ± 159	3351 ± 293
Turn End	[W]	3712 ± 216	3787 ± 344
Key Variable Descriptives			
Maximum Power	[W]	5174 ± 354	5640 ± 462
Maximum Time Point	[%]	32.2 ± 2.2	36.6 ± 3.6
Minimum Power	[W]	2909 ± 155	3167 ± 284
Minimum Time Point	[%]	80.3 ± 2.2	86.8 ± 1.9
Mean Power	[W]	4046 ± 225	4578 ± 350

TABLE G.19. Energy dissipation descriptive statistics. Values are means ± standard deviations (n = 6).

		10 m Course	13 m Course
Turn Cycle Descriptives			
Turn Start	[J·kg^{-1}·m^{-1}]	0.80 ± 1.55	2.53 ± 1.20
Initiation Phase Mean	[J·kg^{-1}·m^{-1}]	2.85 ± 0.72	3.85 ± 1.08
Turn Phase 1 Mean	[J·kg^{-1}·m^{-1}]	16.13 ± 2.90	12.82 ± 1.88
Gate Passage	[J·kg^{-1}·m^{-1}]	21.01 ± 3.29	18.57 ± 3.75
Turn Phase 2 Mean	[J·kg^{-1}·m^{-1}]	13.75 ± 1.70	15.60 ± 1.24
Completion Phase Mean	[J·kg^{-1}·m^{-1}]	4.03 ± 0.92	7.90 ± 1.24
Turn End	[J·kg^{-1}·m^{-1}]	0.58 ± 2.43	2.52 ± 2.34
Key Variable Descriptives			
Maximum Dissipation	[J·kg^{-1}·m^{-1}]	23.46 ± 1.79	22.02 ± 2.34
Maximum Time Point	[%]	50.50 ± 6.67	64.3 ± 6.8
Minimum Dissipation	[J·kg^{-1}·m^{-1}]	–2.18 ± 1.29	–0.60 ± 1.33
Minimum Time Point	[%]		
Mean Dissipation	[J·kg^{-1}·m^{-1}]	8.85 ± 0.71	9.43 ± 0.76

APPENDIX H. Individual Ski and Center of Mass Turn Radius Data

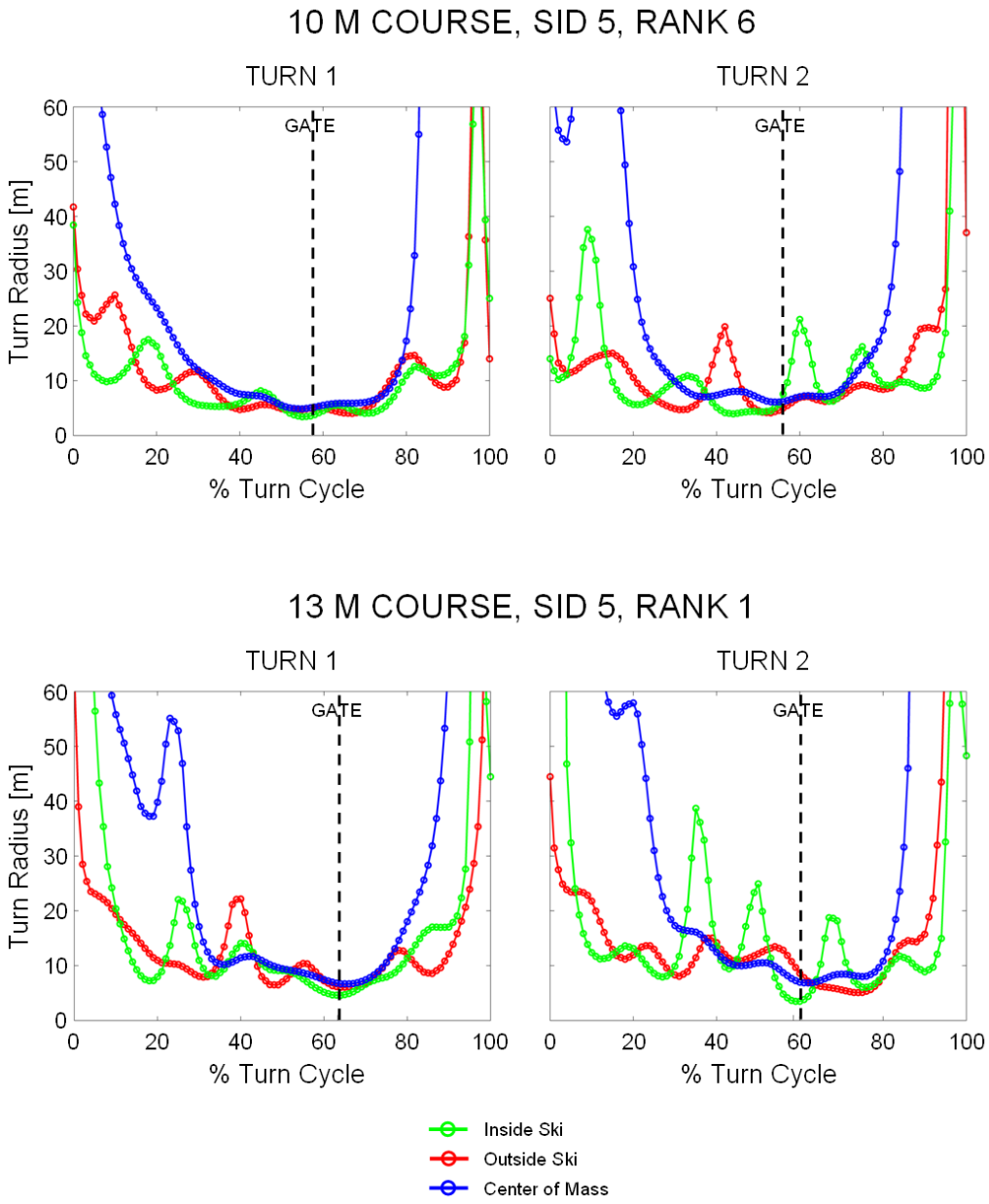


FIGURE H.1. Ski and center of mass turn radius for subject 5 on both the 10 and 13 m courses.

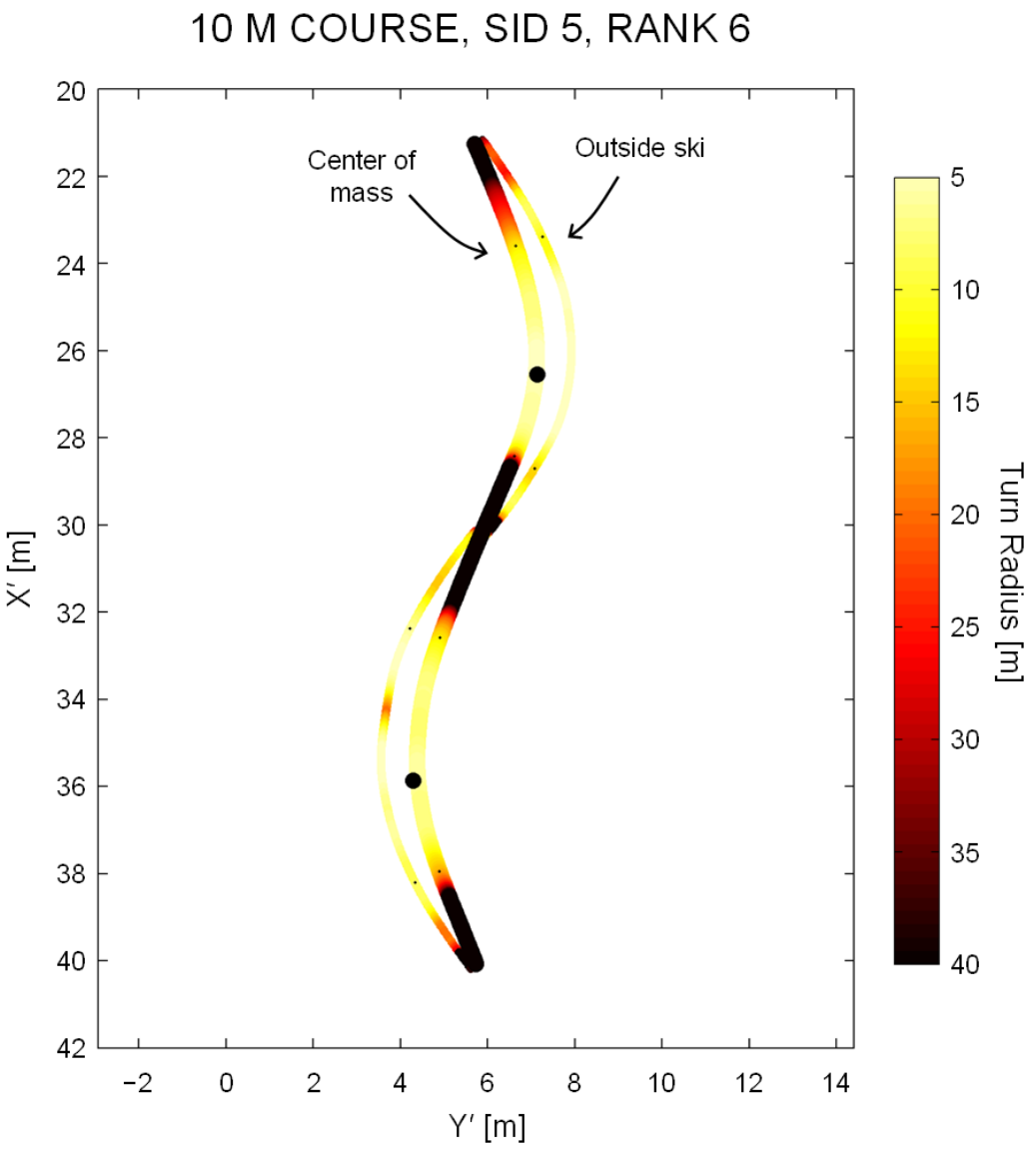


FIGURE H.2. Outside ski and center of mass trajectories for Subject 5 on the 10 m course. Color indicates trajectory turn radius.

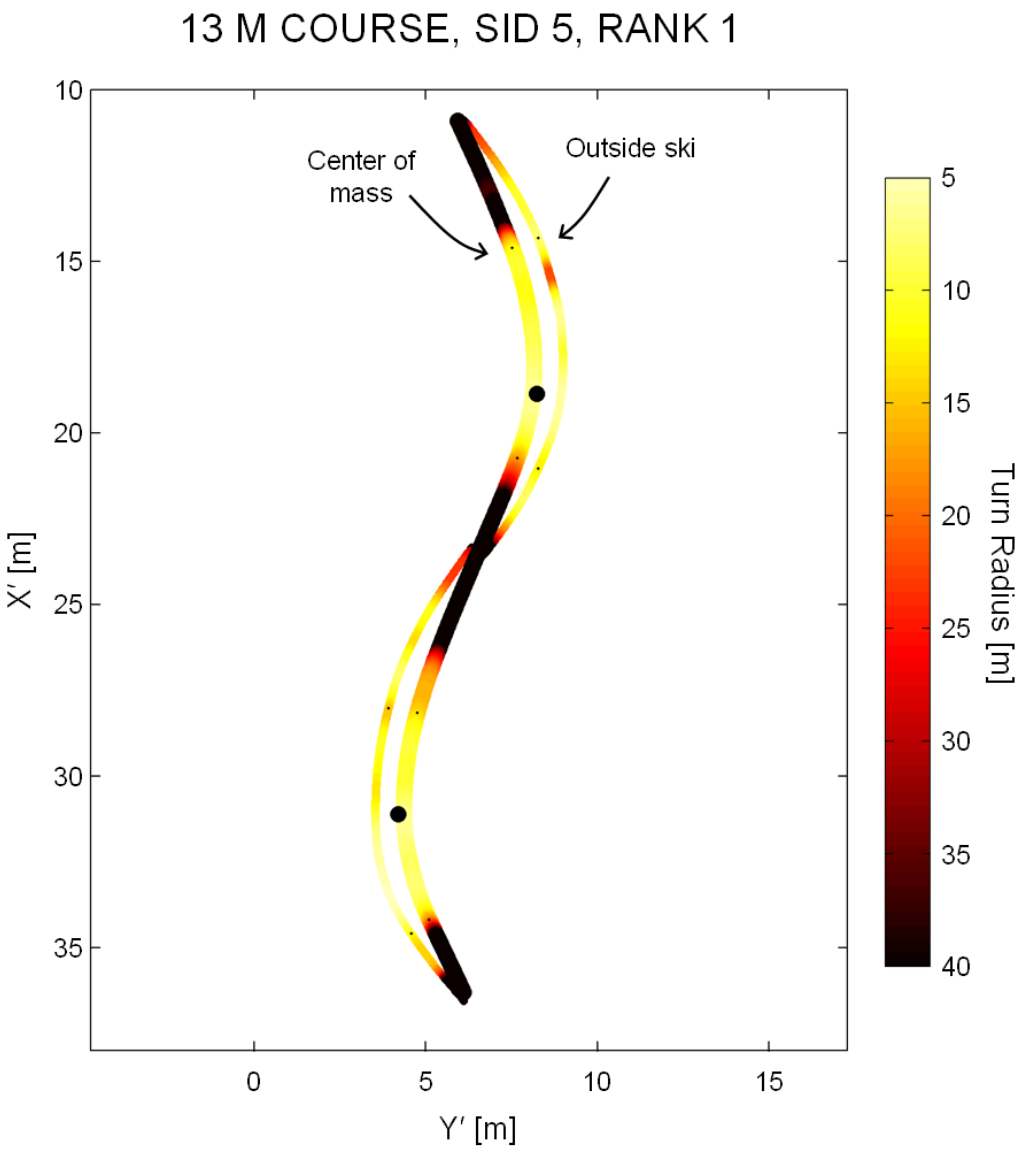


FIGURE H.3. Outside ski and center of mass trajectories for Subject 5 on the 13 m Course. Color indicates trajectory turn radius.

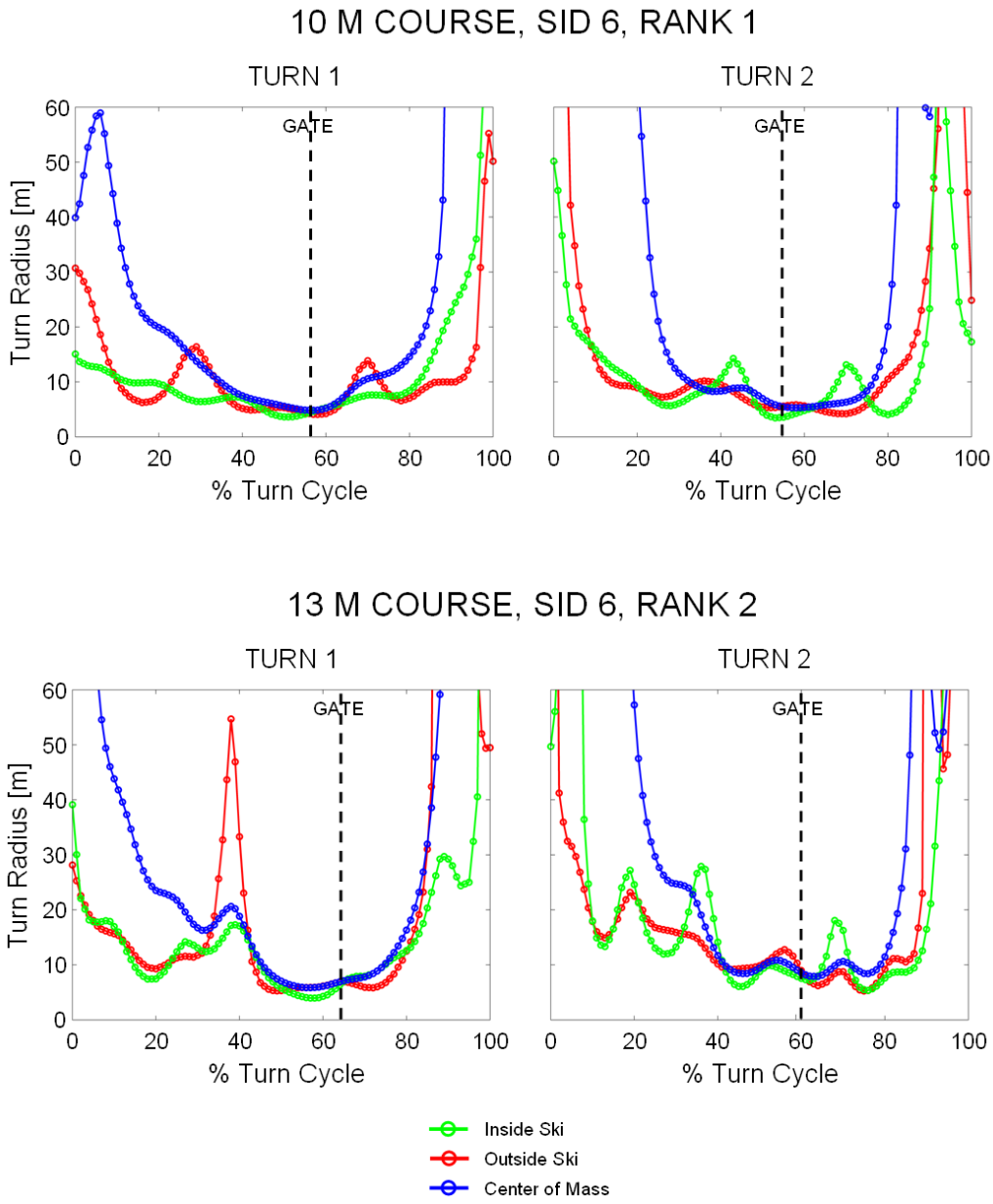


FIGURE H.4. Ski and center of mass turn radius for subject 6 on both the 10 and 13 m courses.

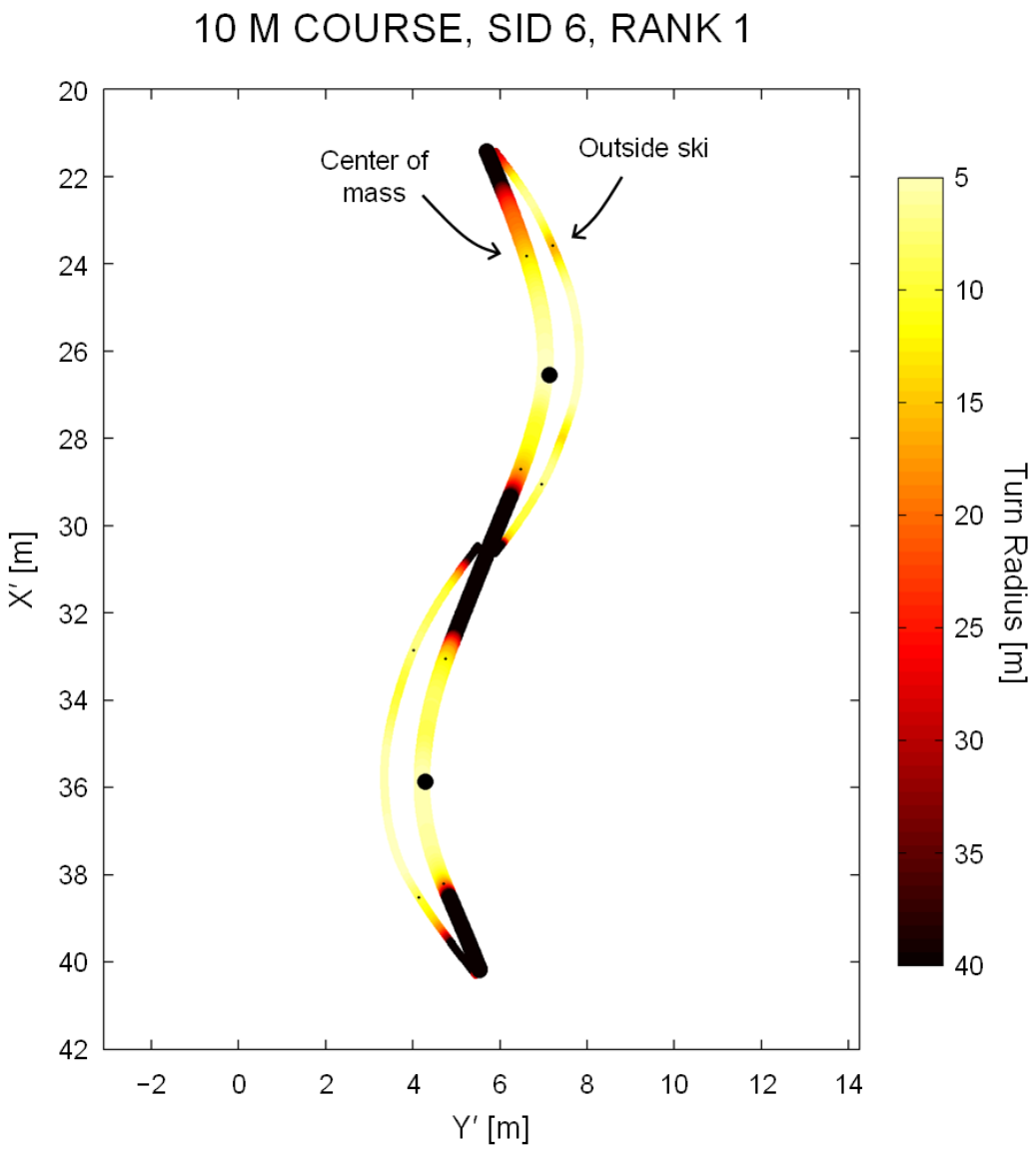


FIGURE H.5. Outside ski and center of mass trajectories for Subject 6 on the 10 m Course. Color indicates trajectory turn radius.

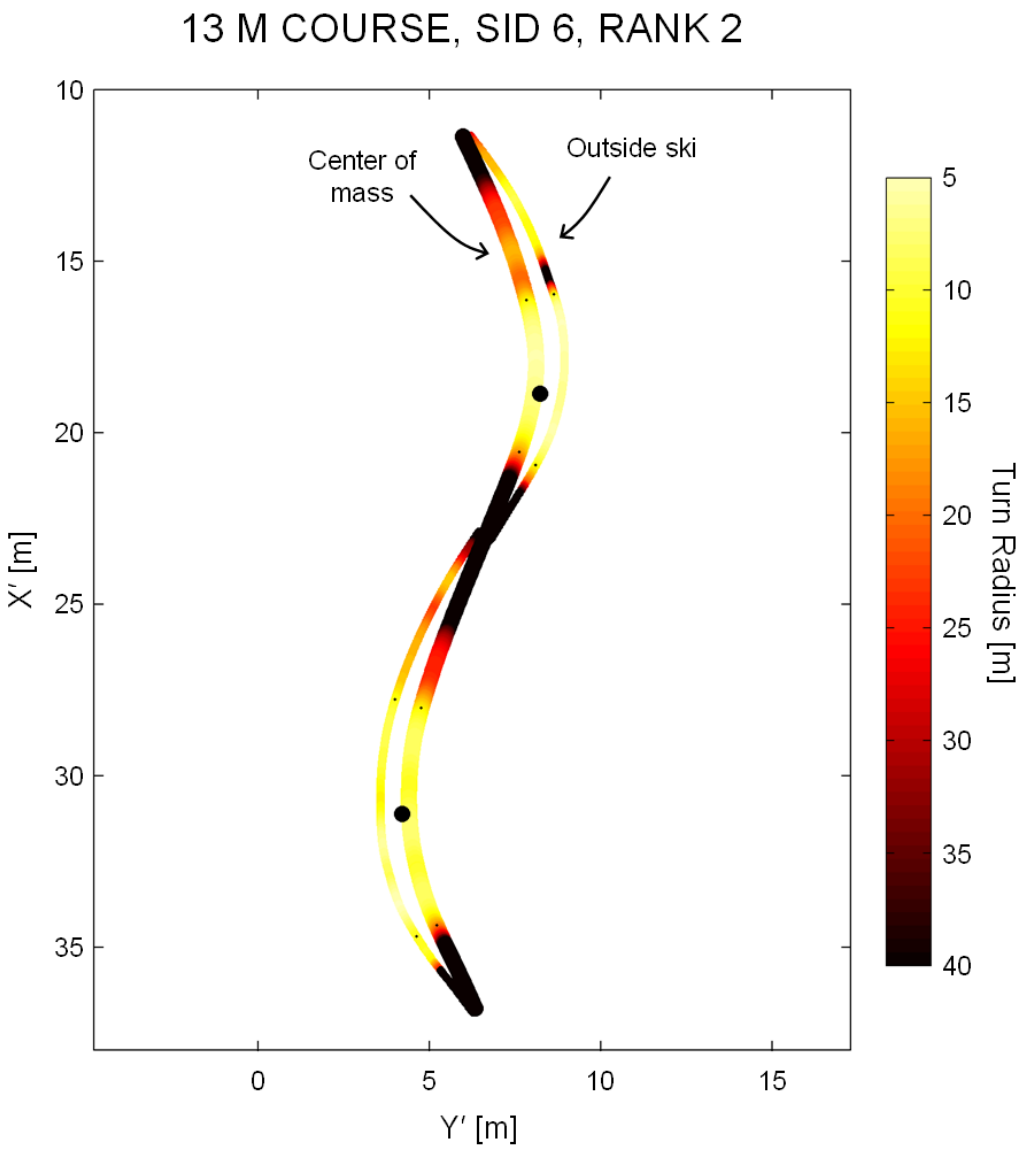


FIGURE H.6. Outside ski and center of mass trajectories for Subject 6 on the 13 m Course. Color indicates trajectory turn radius.

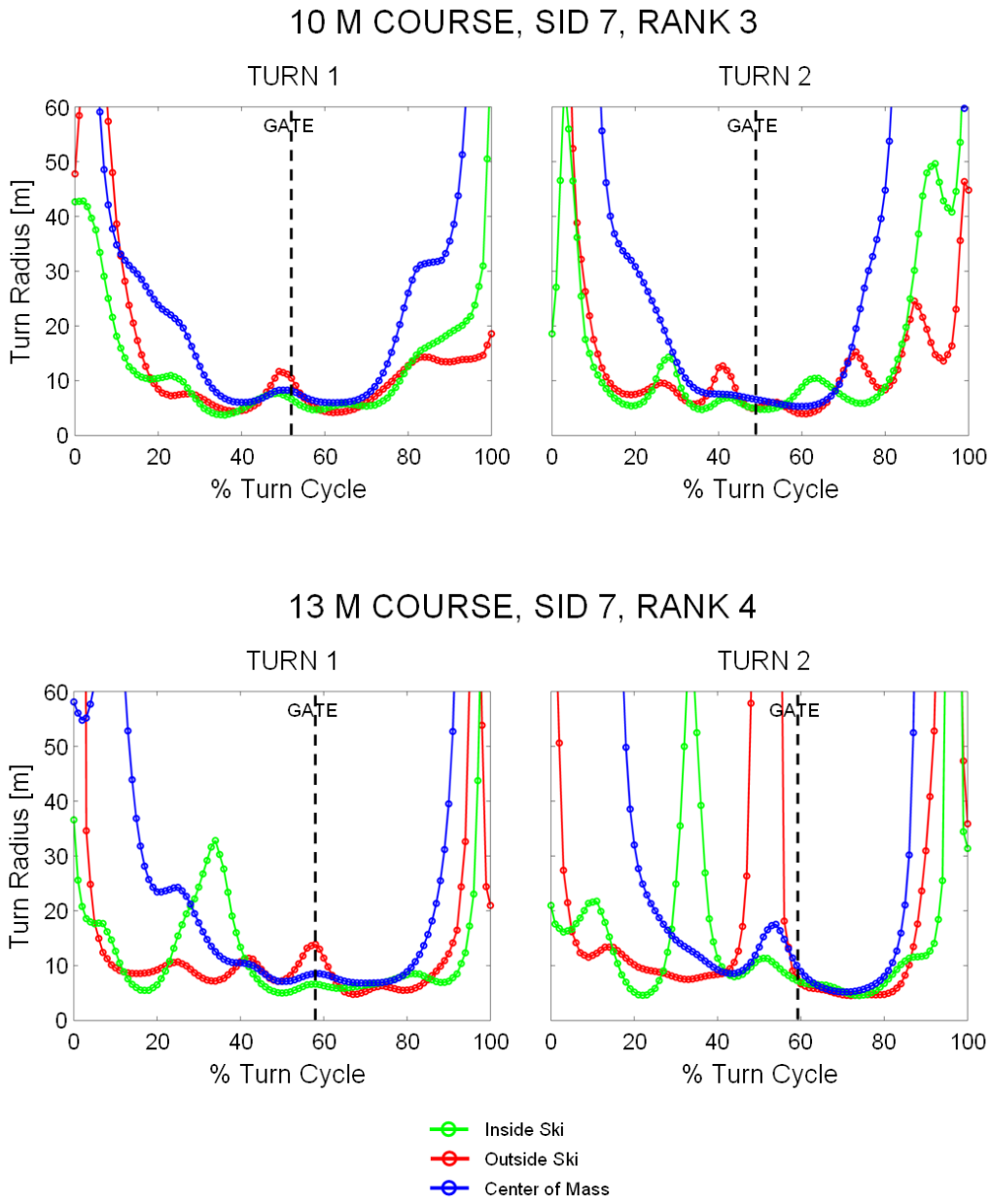


FIGURE H.7. Ski and center of mass turn radius for subject 7 on both the 10 and 13 m courses.

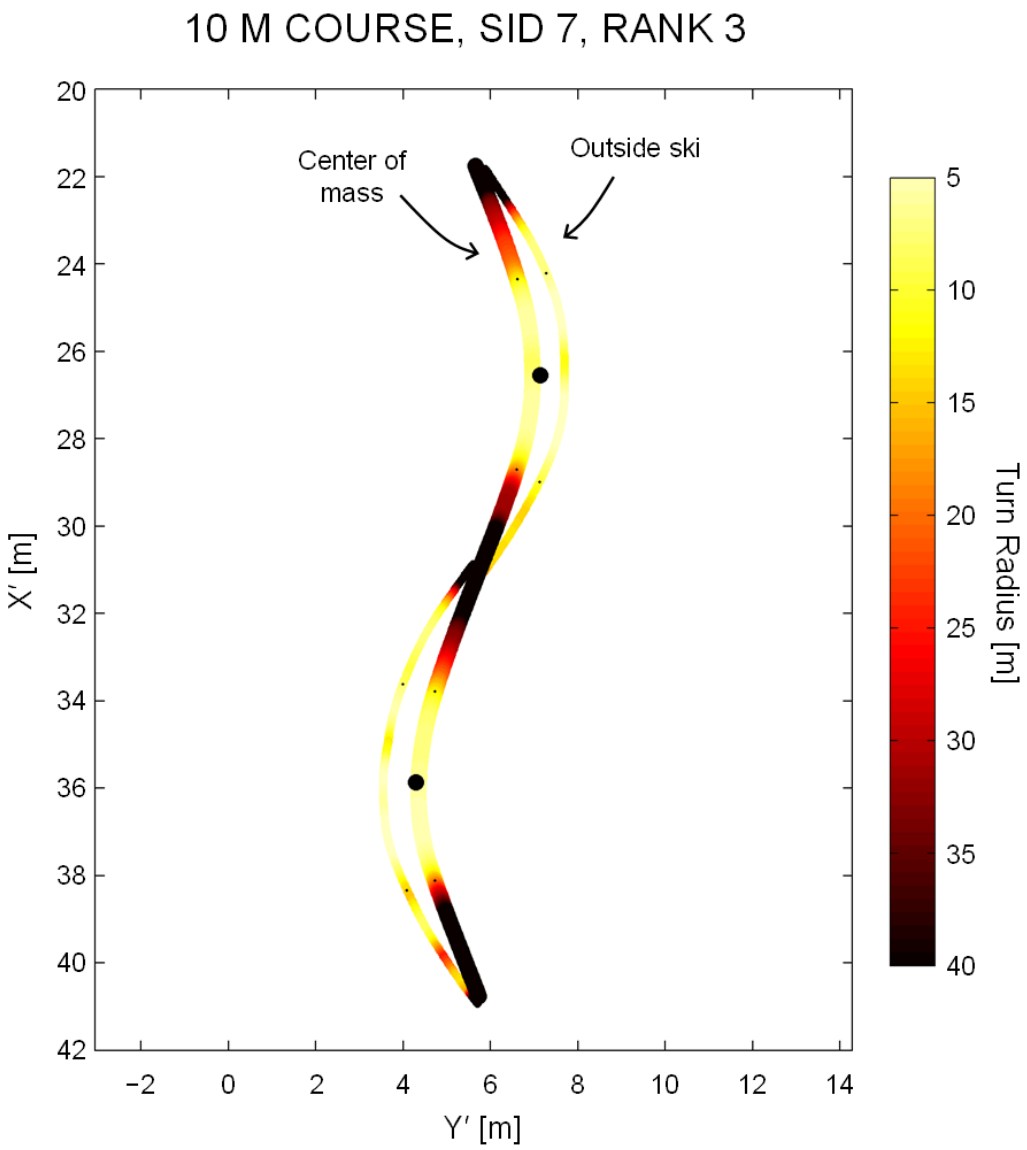


FIGURE H.8. Outside ski and center of mass trajectories for Subject 7 on the 10 m Course. Color indicates trajectory turn radius.

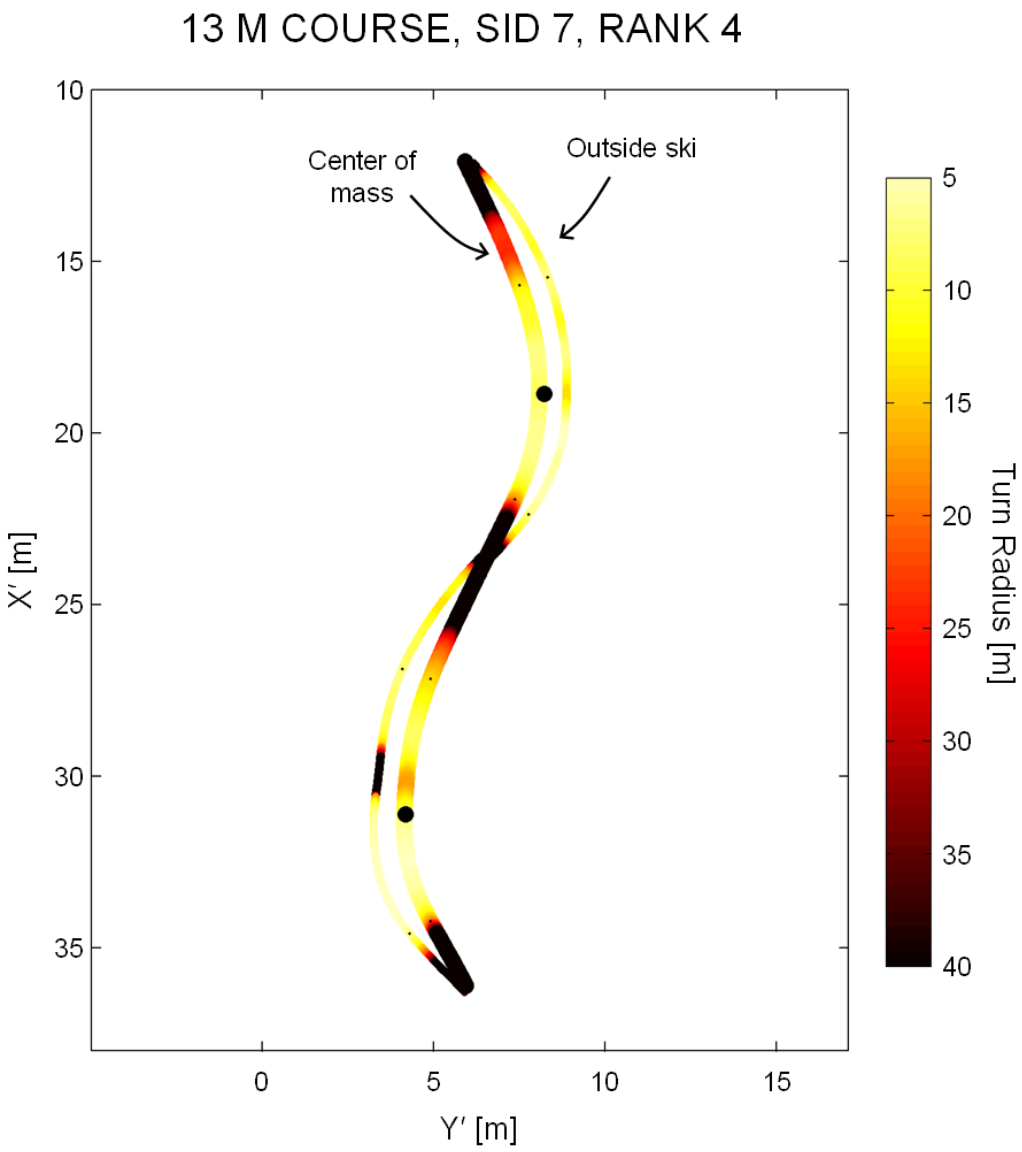


FIGURE H.9. Outside ski and center of mass trajectories for Subject 7 on the 13 m Course. Color indicates trajectory turn radius.

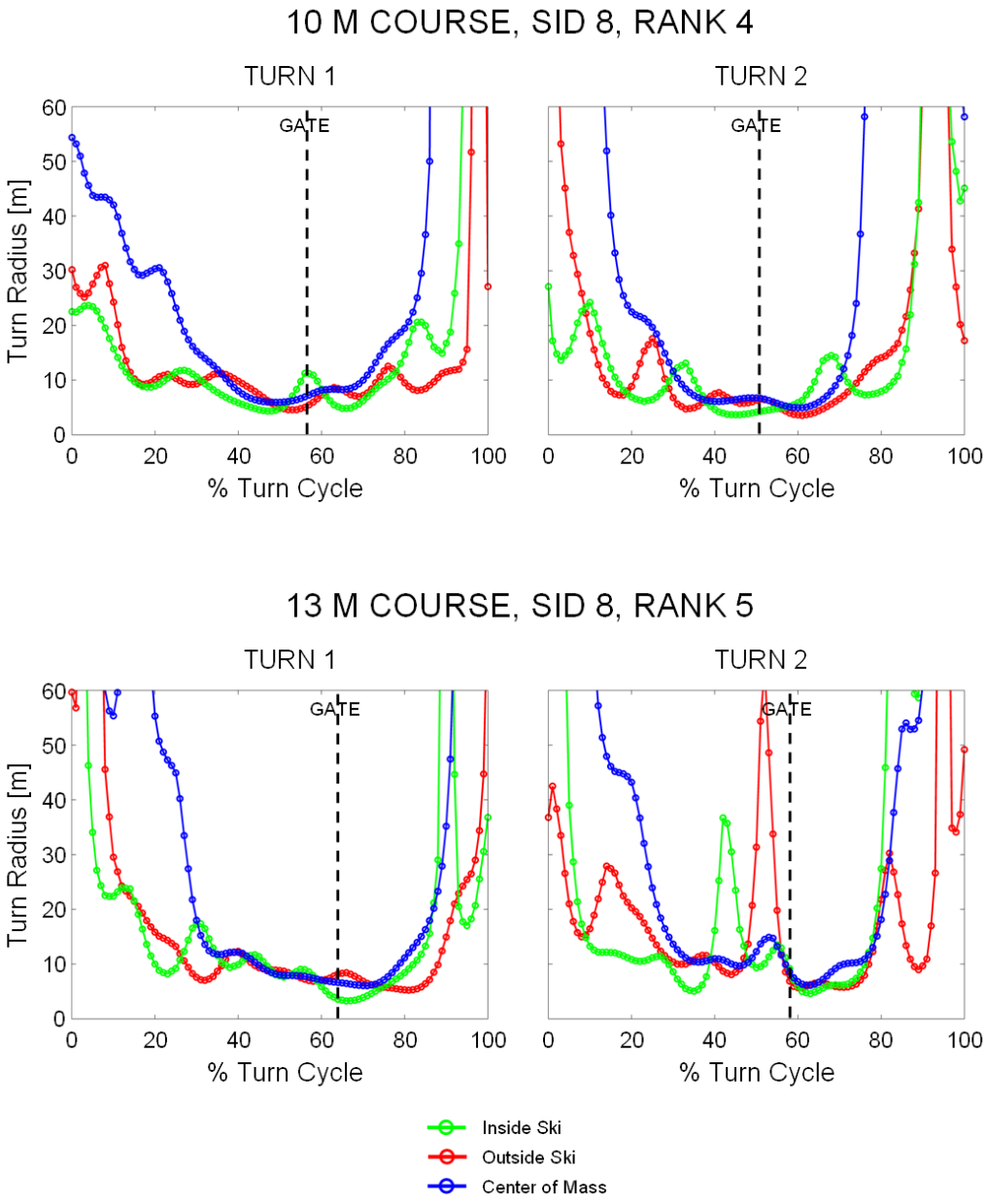


FIGURE H.10. Ski and center of mass turn radius for subject 8 on both the 10 and 13 m courses.

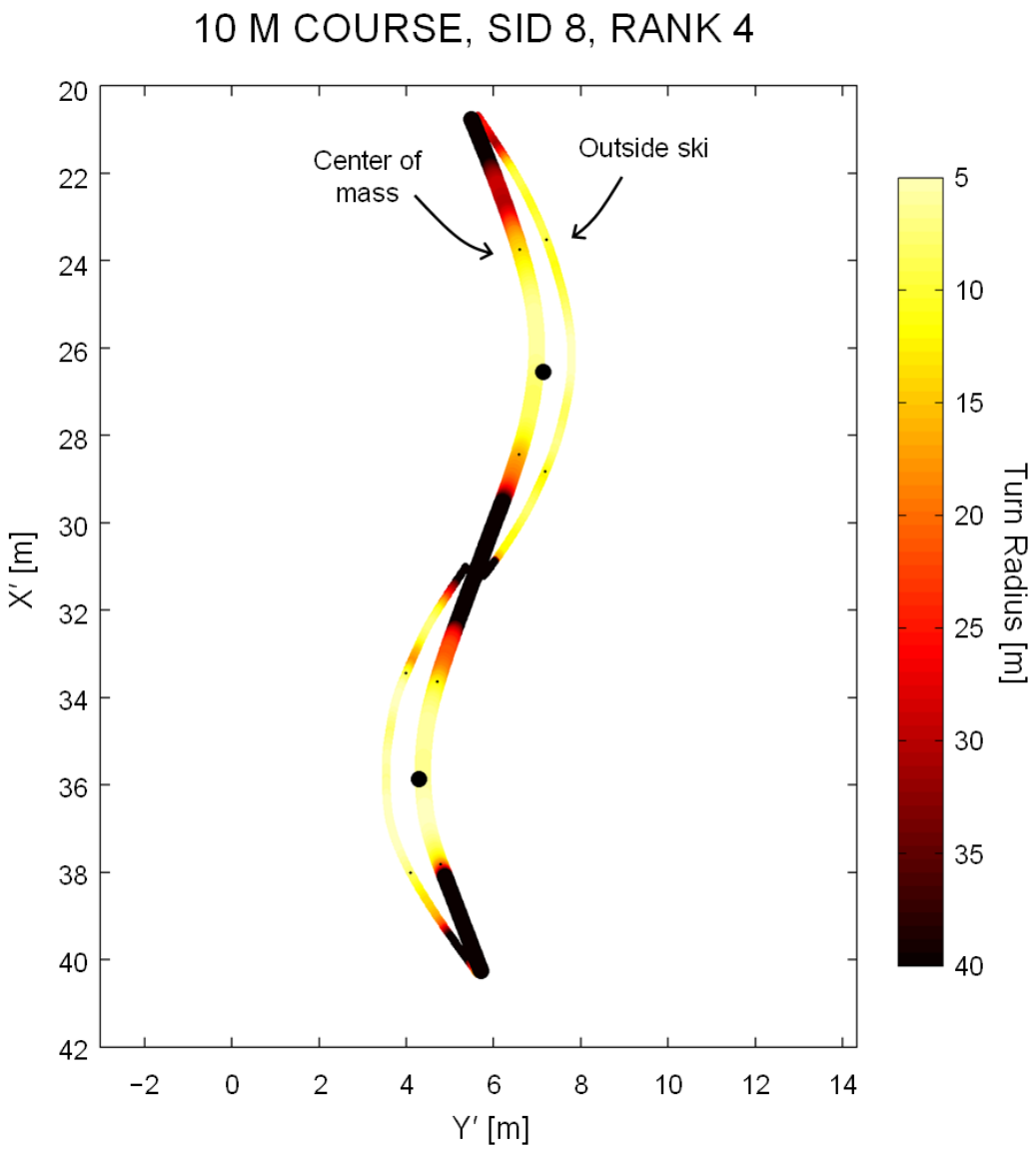


FIGURE H.11. Outside ski and center of mass trajectories for Subject 8 on the 10 m Course. Color indicates trajectory turn radius.

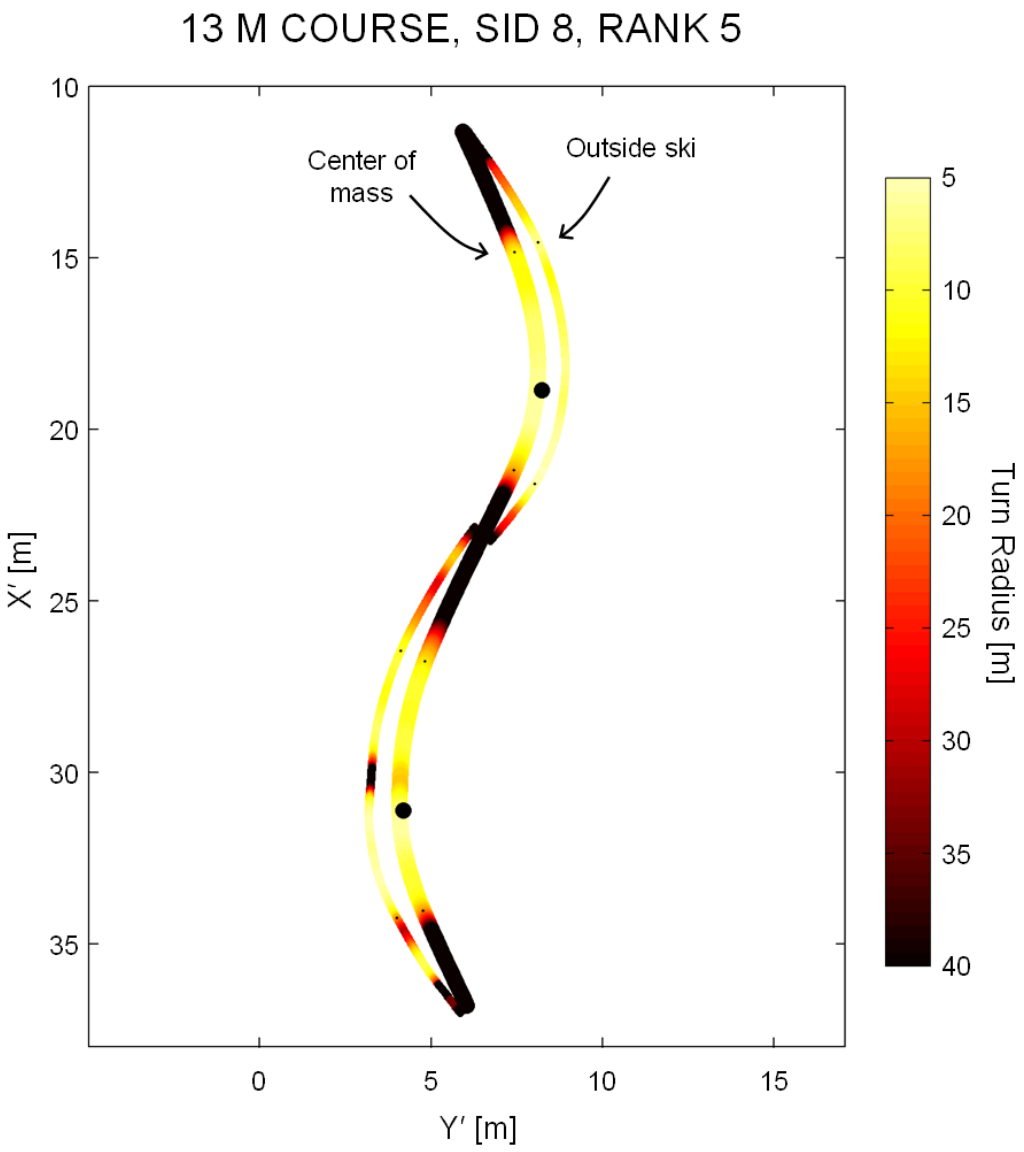


FIGURE H.12. Outside ski and center of mass trajectories for Subject 8 on the 13 m Course. Color indicates trajectory turn radius.

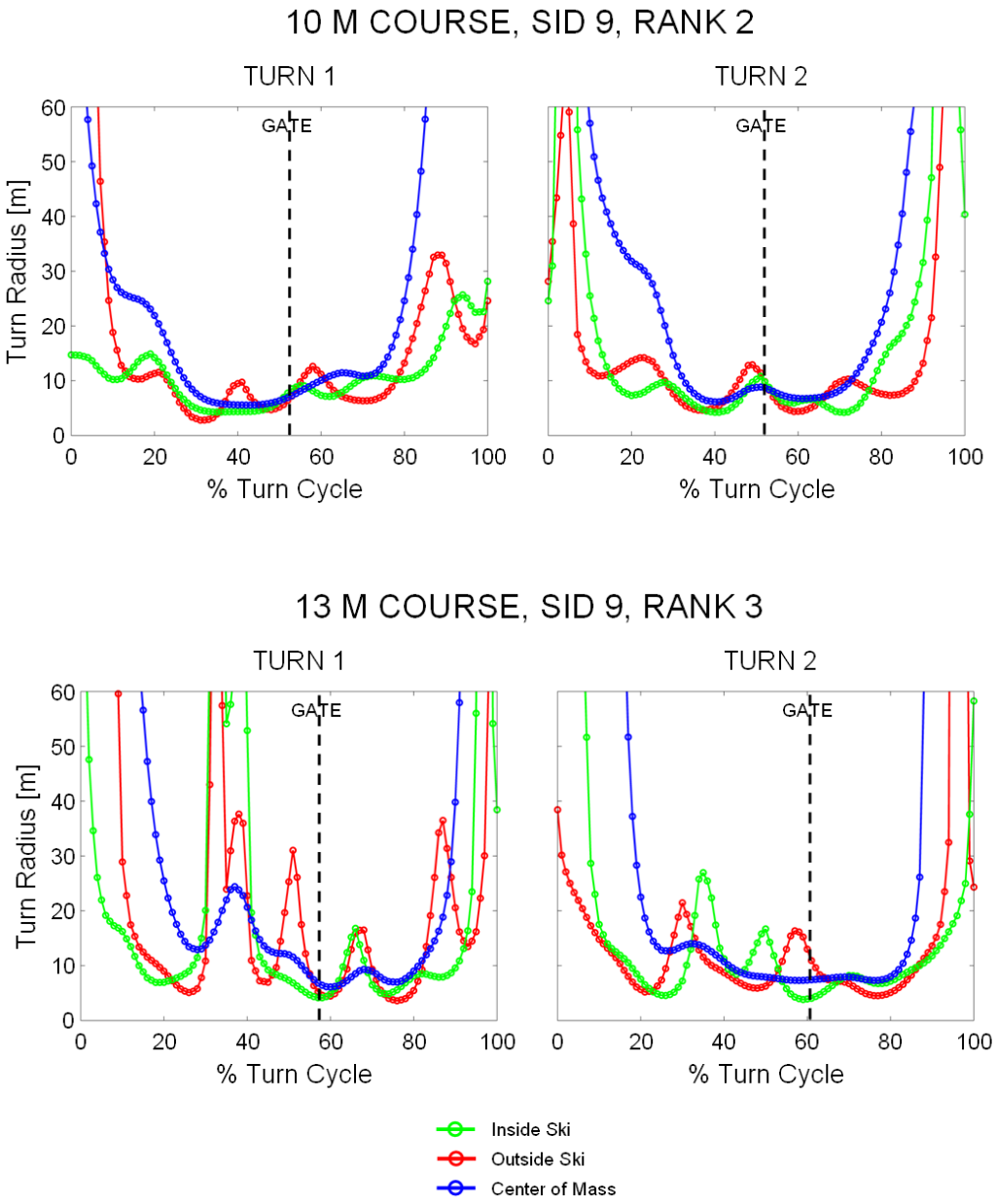


FIGURE H.13. Ski and center of mass turn radius for subject 9 on both the 10 and 13 m courses.

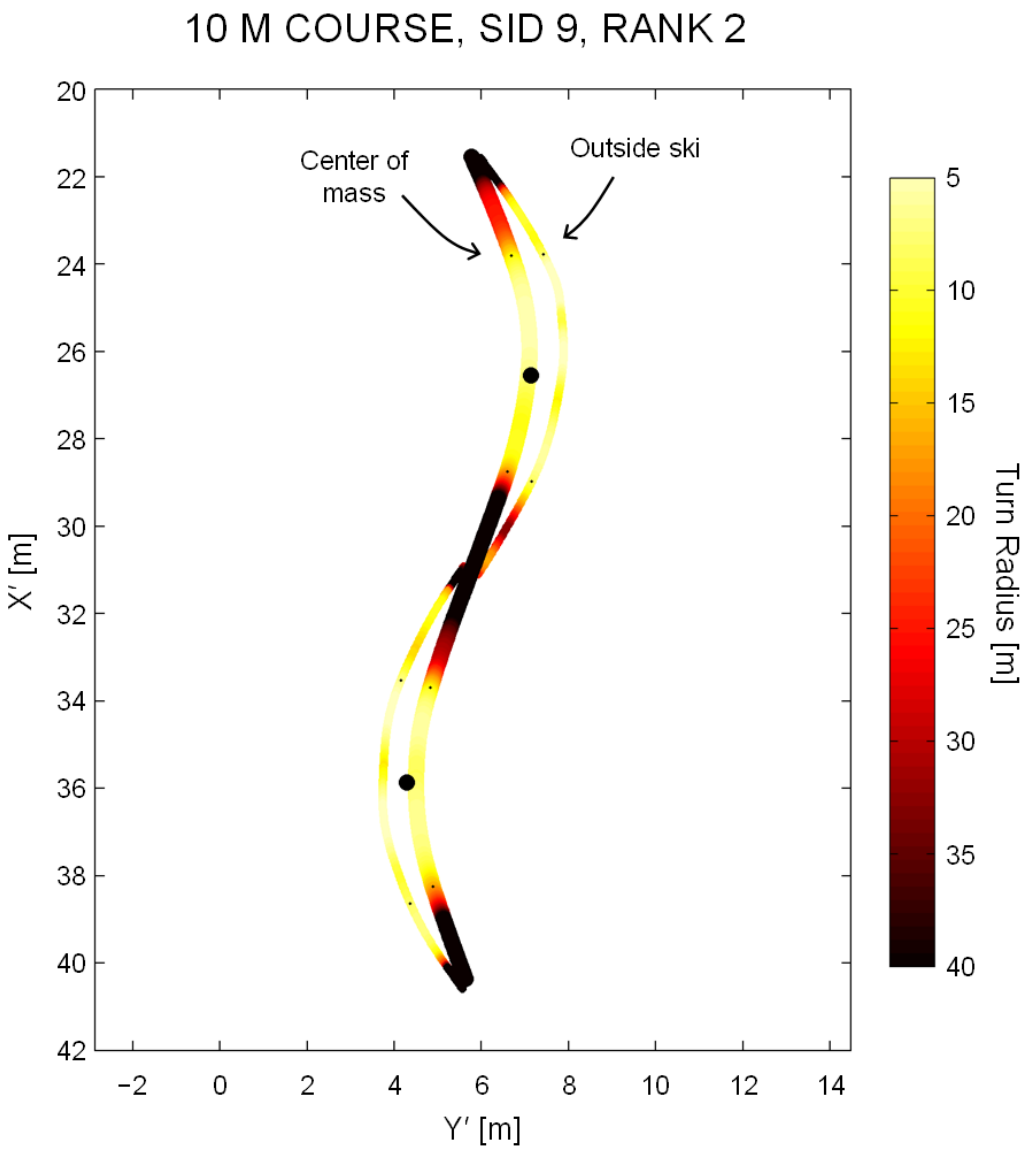


FIGURE H.14. Outside ski and center of mass trajectories for Subject 9 on the 10 m Course. Color indicates trajectory turn radius.

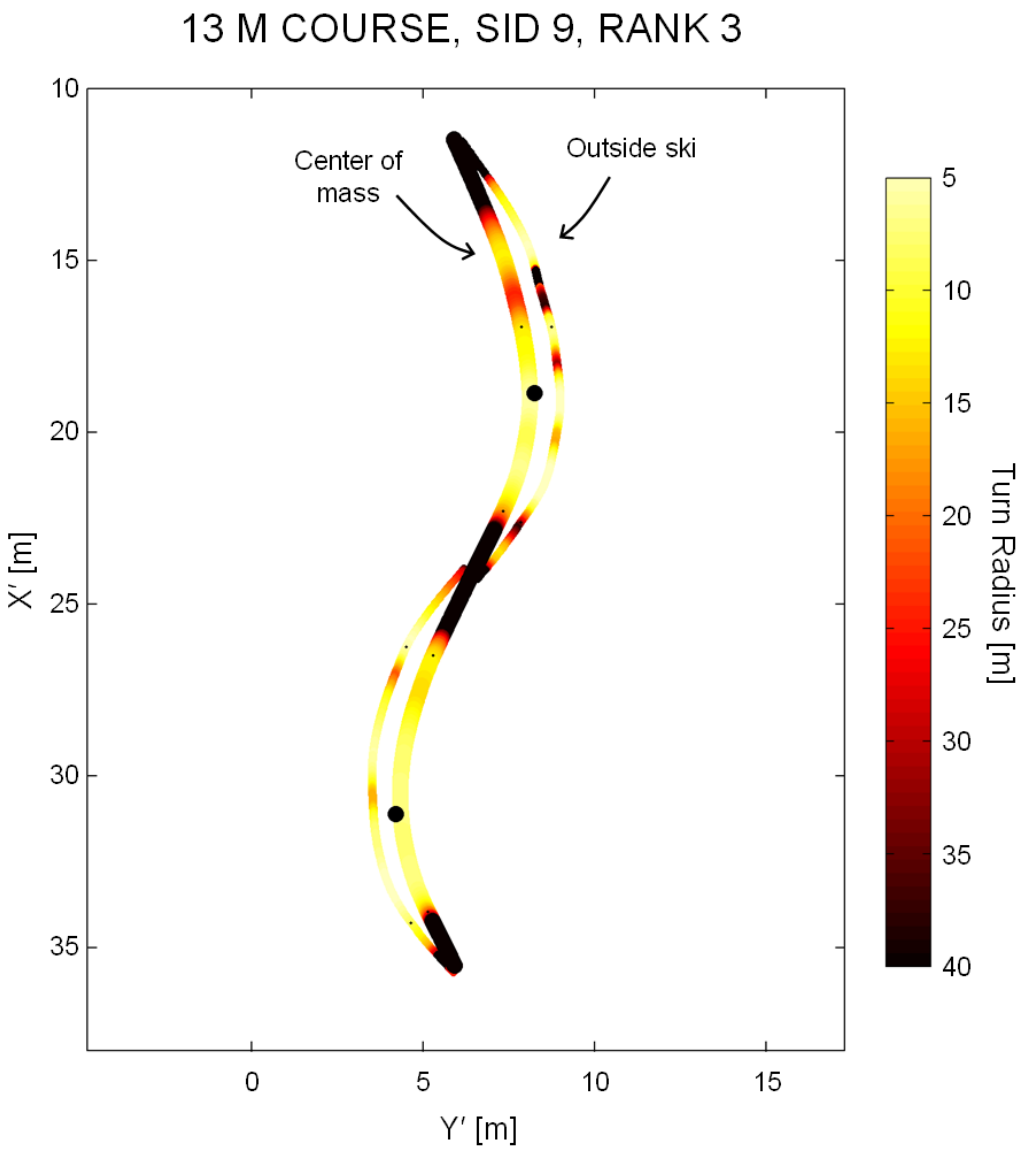


FIGURE H.15. Outside ski and center of mass trajectories for Subject 9 on the 13 m Course. Color indicates trajectory turn radius.

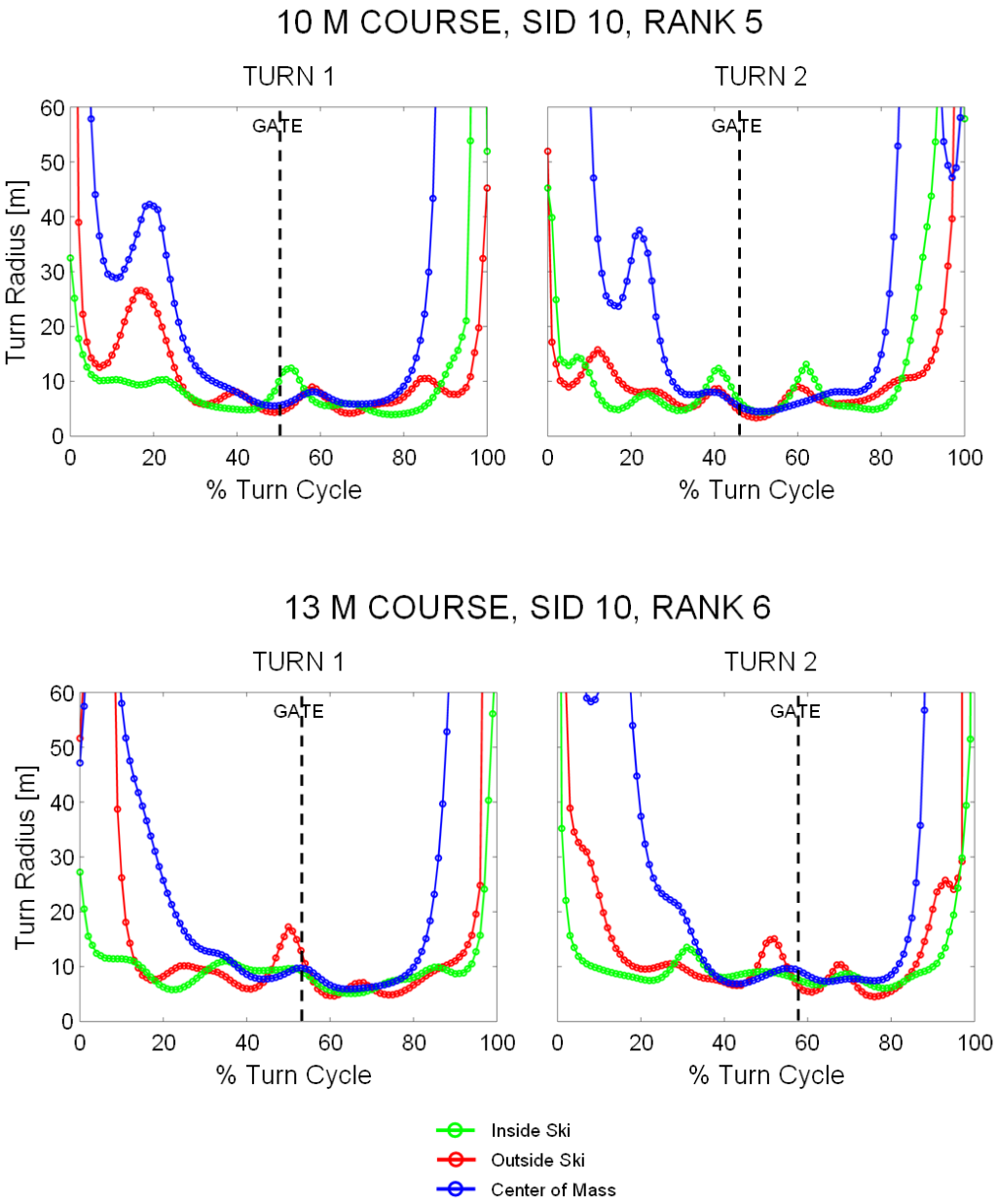


FIGURE H.16. Ski and center of mass turn radius for subject 10 on both the 10 and 13 m courses.

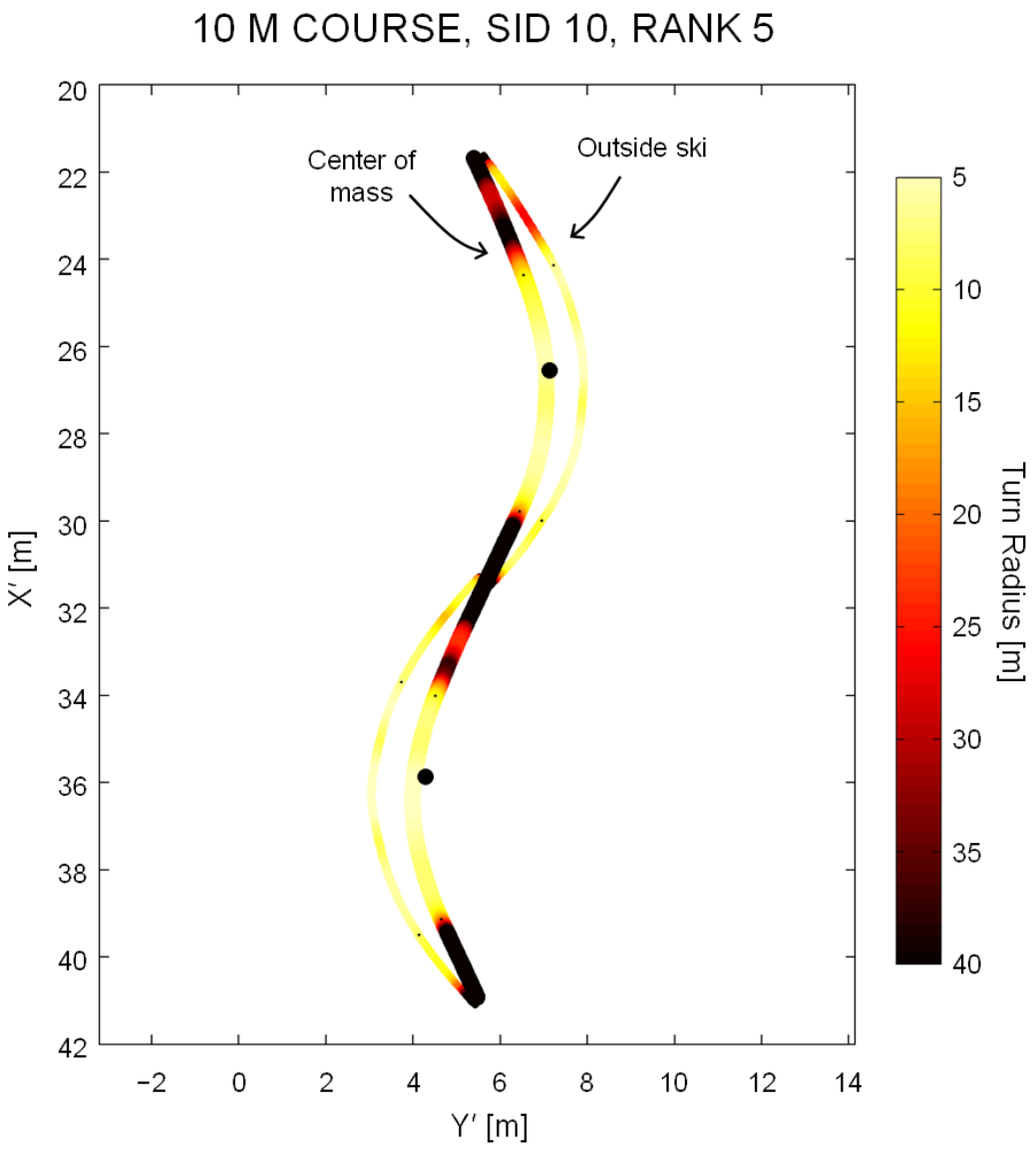


FIGURE H.17. Outside ski and center of mass trajectories for Subject 9 on the 10 m Course. Color indicates trajectory turn radius.

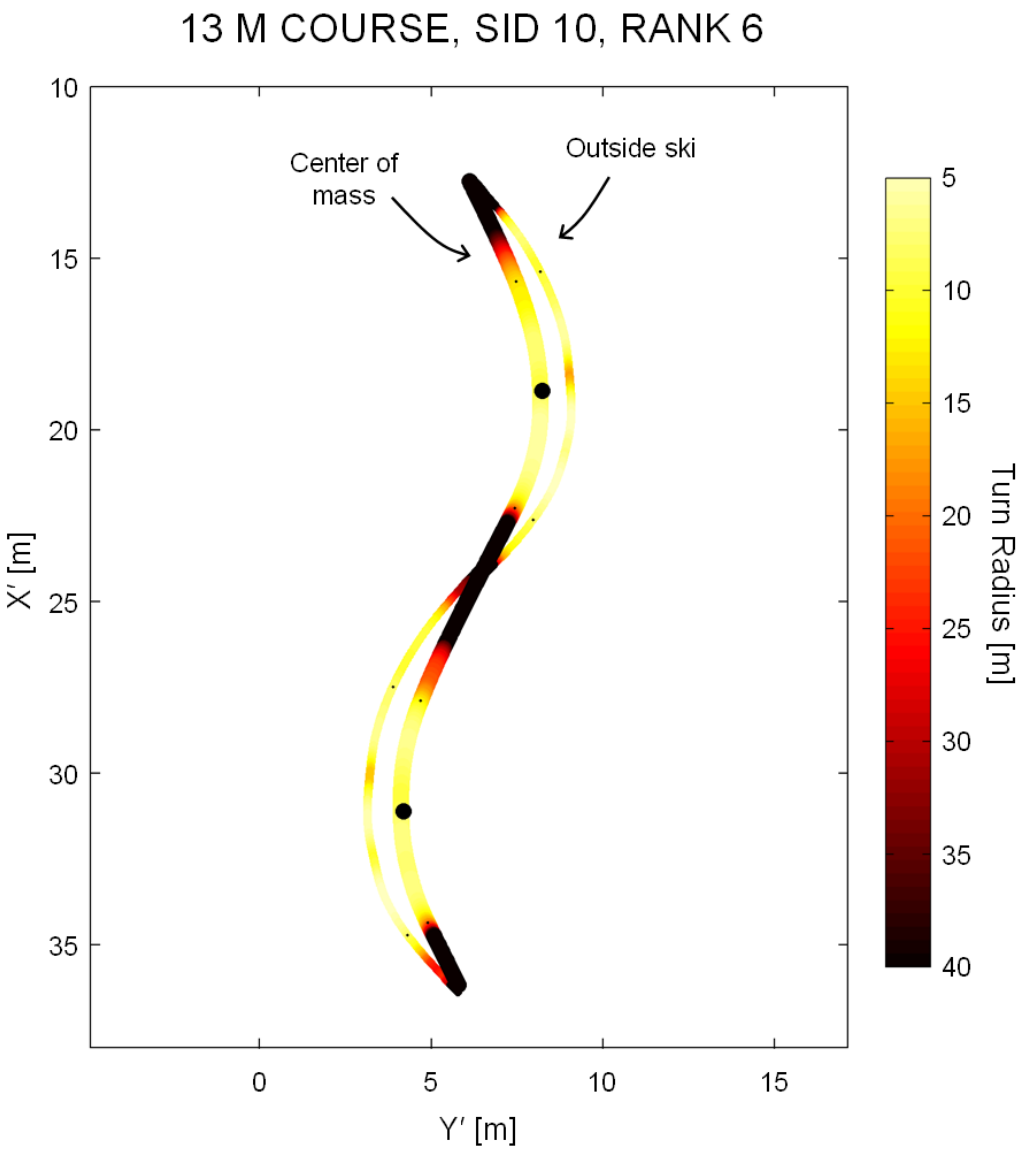


FIGURE H.18. Outside ski and center of mass trajectories for Subject 10 on the 13 m Course. Color indicates trajectory turn radius.

APPENDIX I. Individual Center of Mass Attack Angle Data

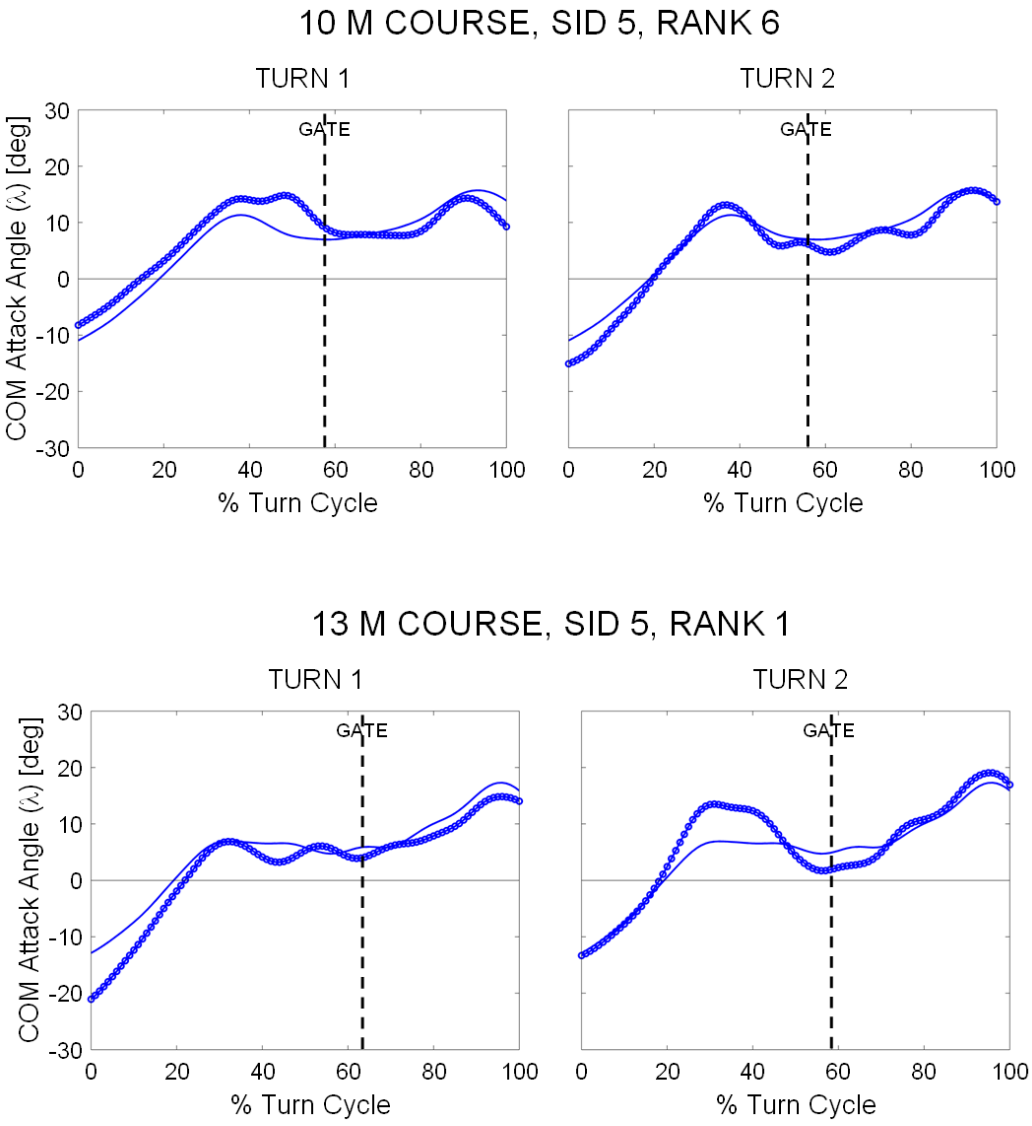


FIGURE I.1. Center of mass attack angle for subject 5 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the ensemble average.

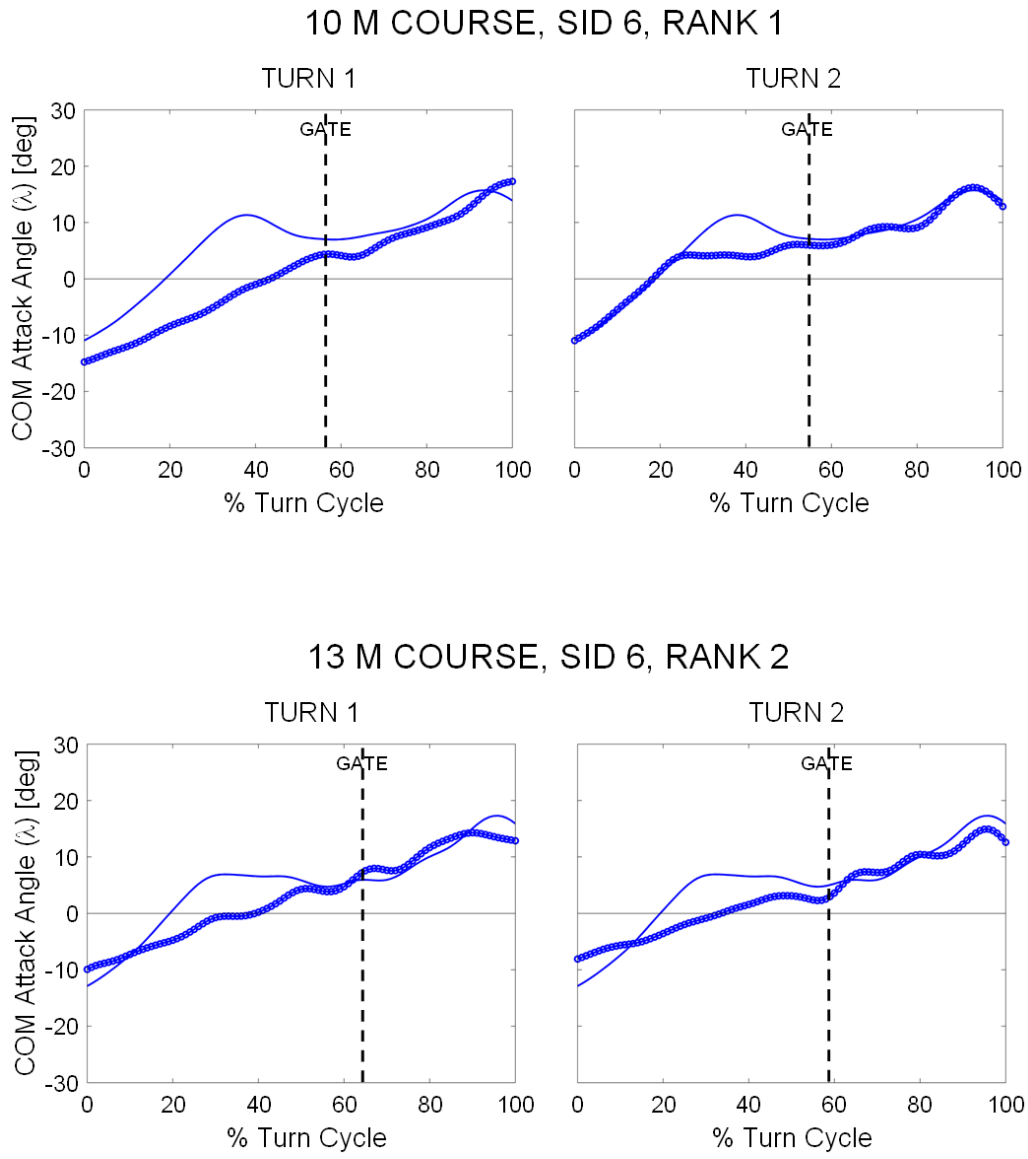


FIGURE I.2. Center of mass attack angle for subject 6 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the ensemble average.

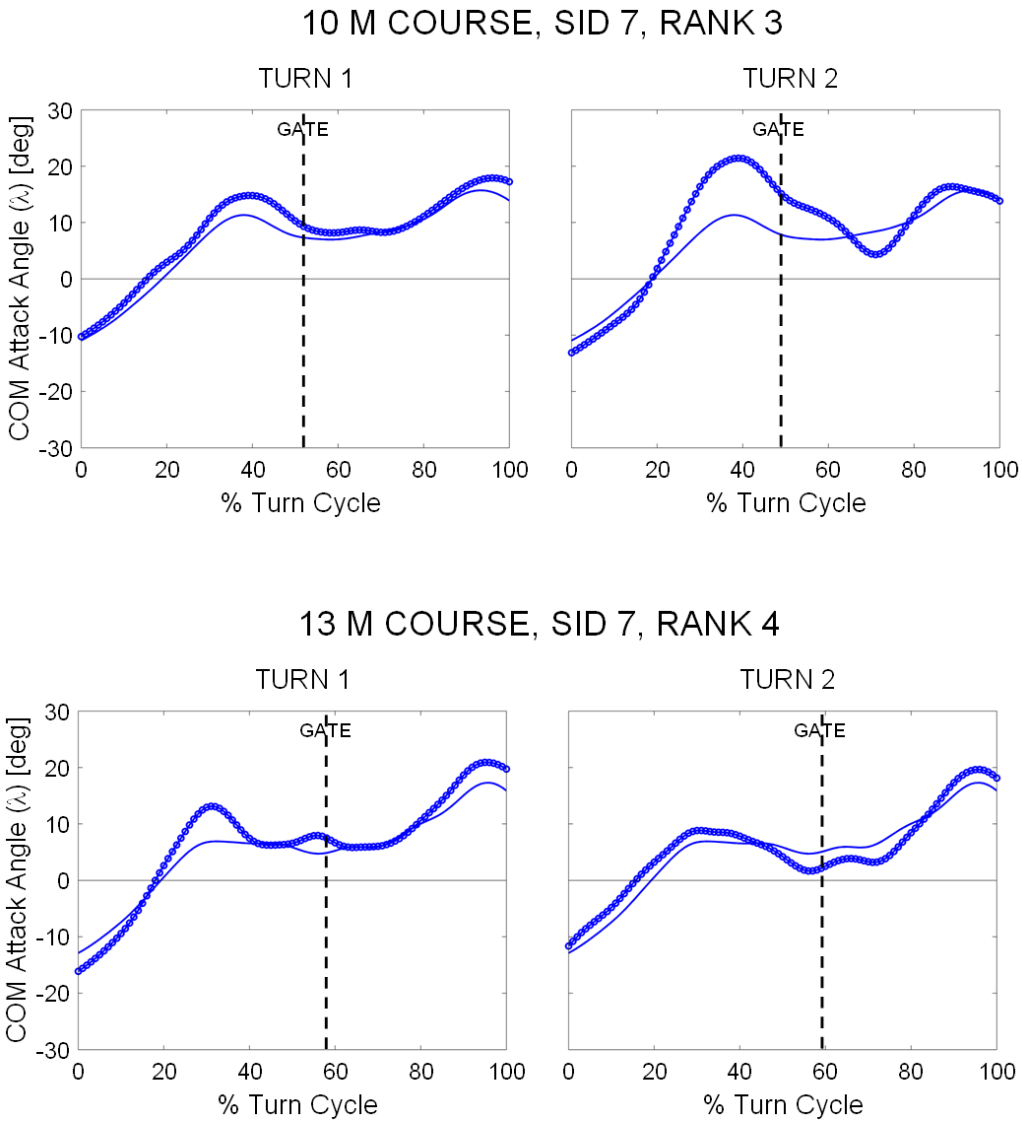


FIGURE I.3. Center of mass attack angle for subject 7 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the ensemble average.

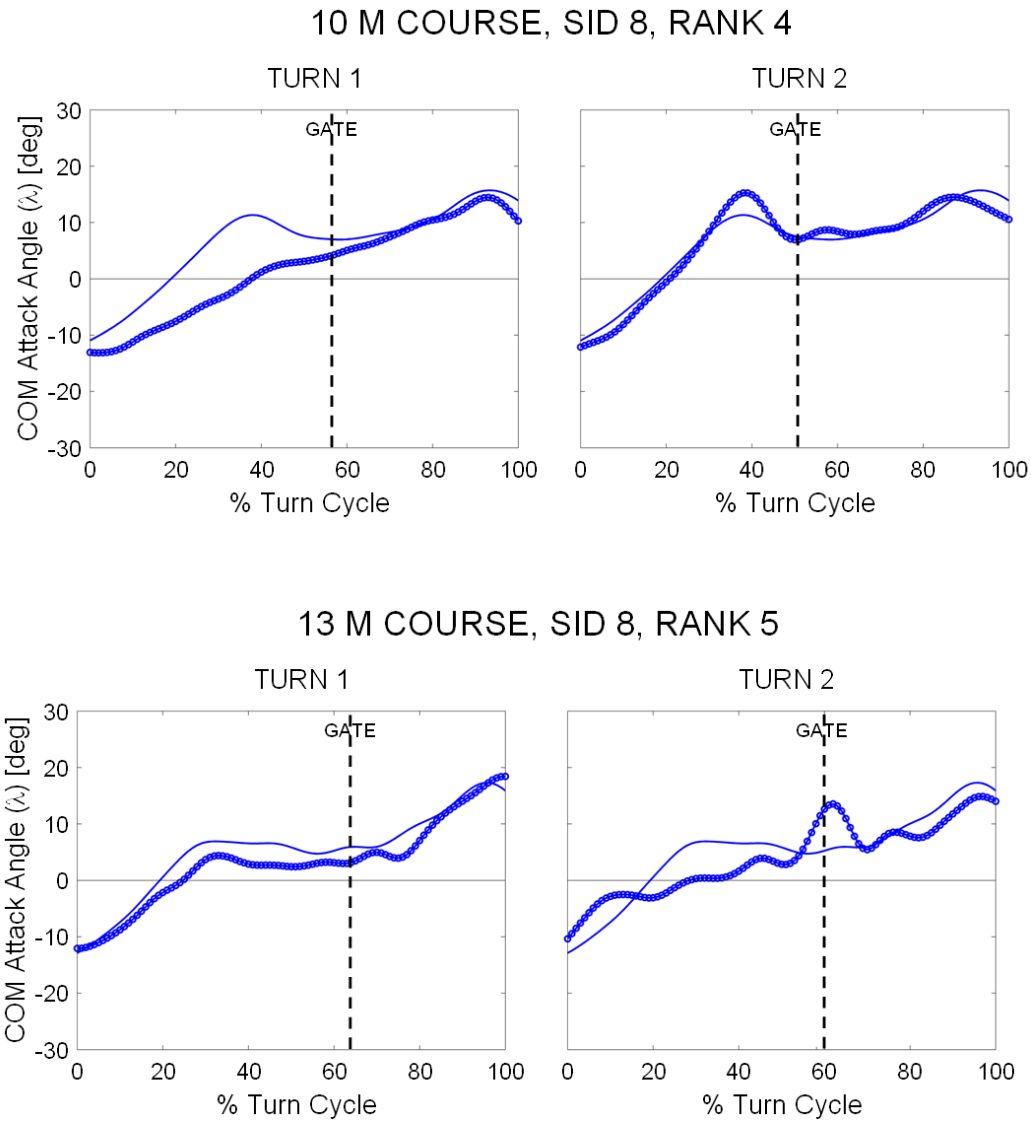


FIGURE I.4. Center of mass attack angle for subject 8 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the ensemble average.

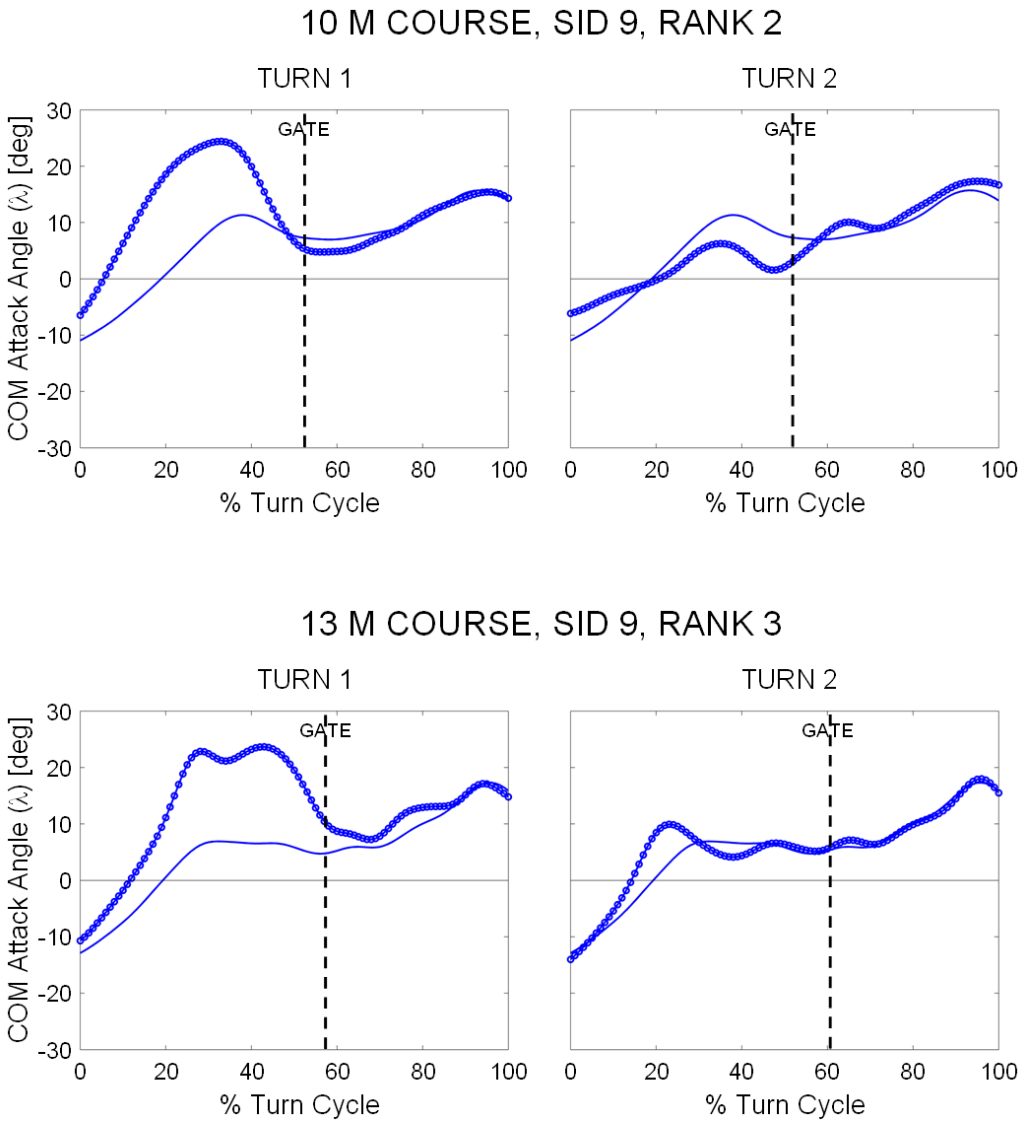


FIGURE I.5. Center of mass attack angle for subject 9 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the ensemble average.

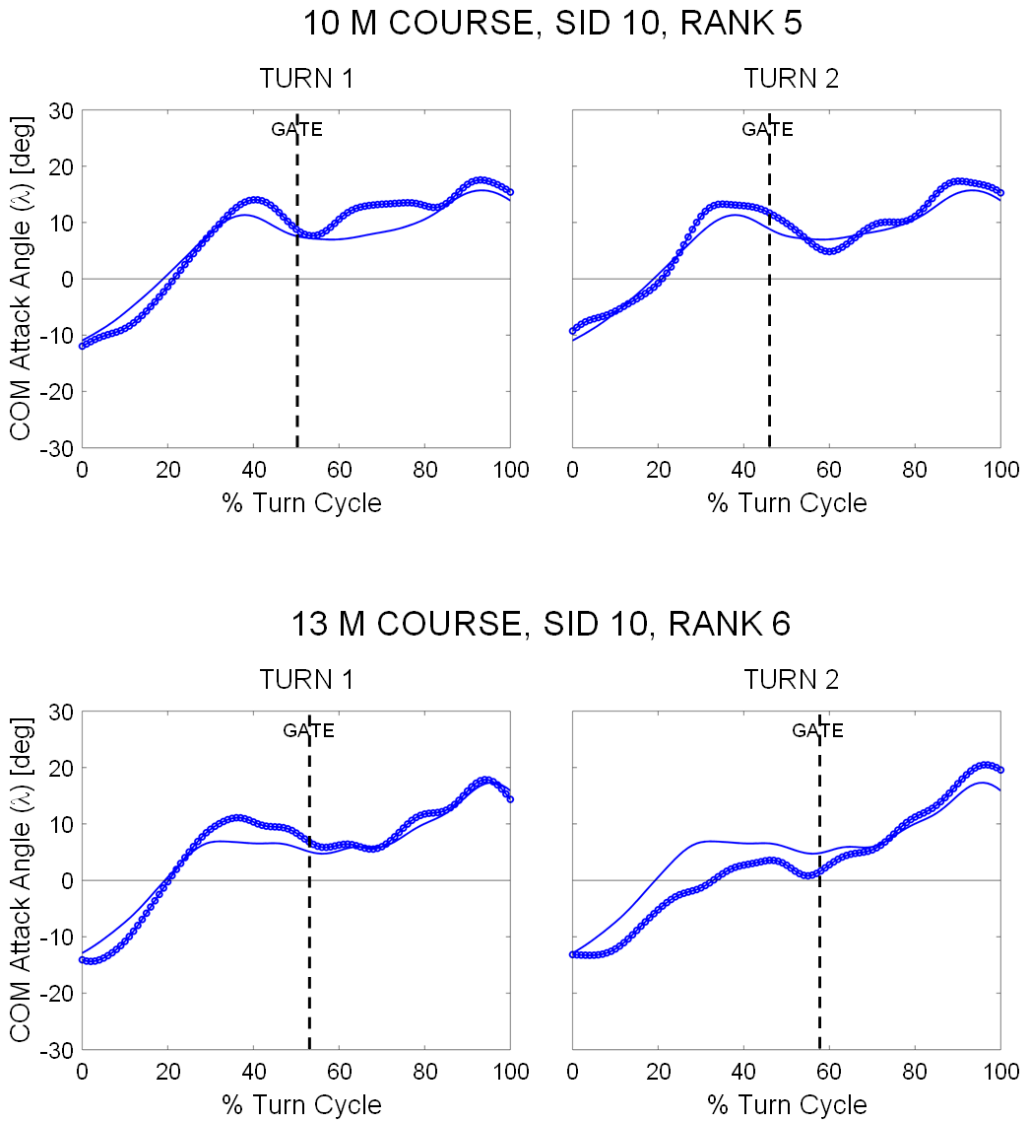


FIGURE I.6. Center of mass attack angle for subject 10 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the ensemble average.

APPENDIX J. Individual Outside Ski Edge and Attack Angle Data

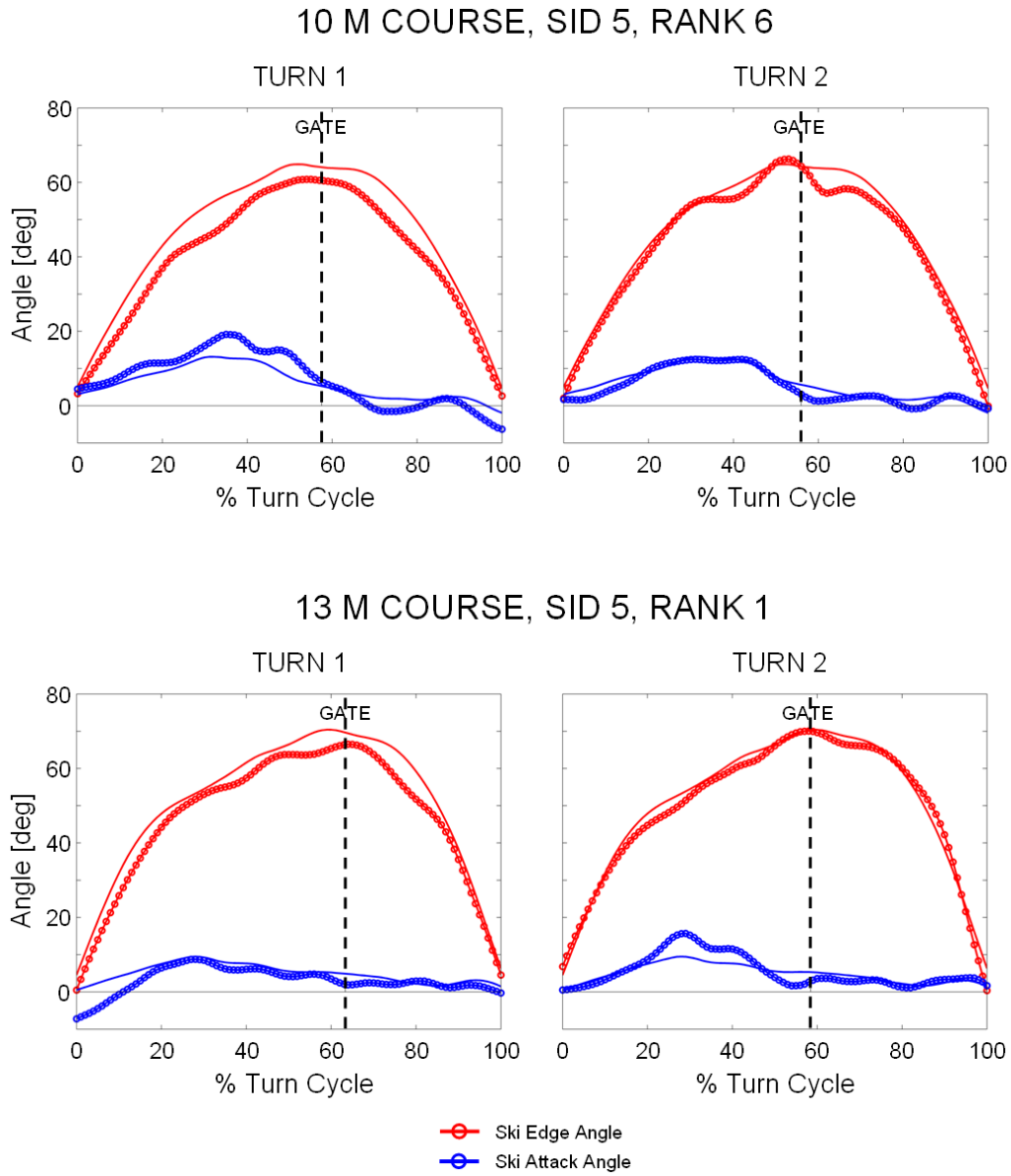


FIGURE J.1. Outside ski edge and attack angle for subject 5 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

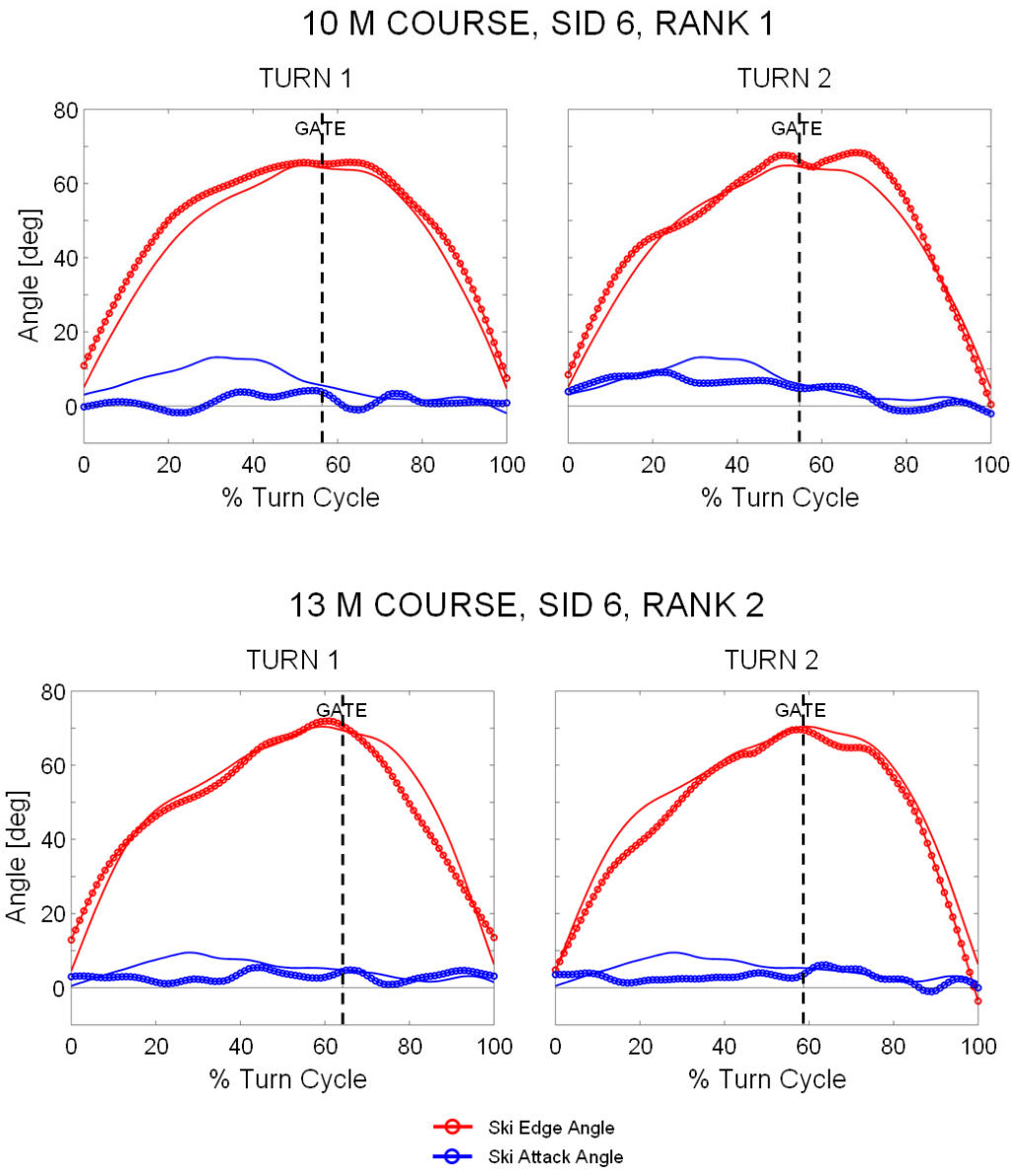


FIGURE J.2. Outside ski edge and attack angle for subject 6 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

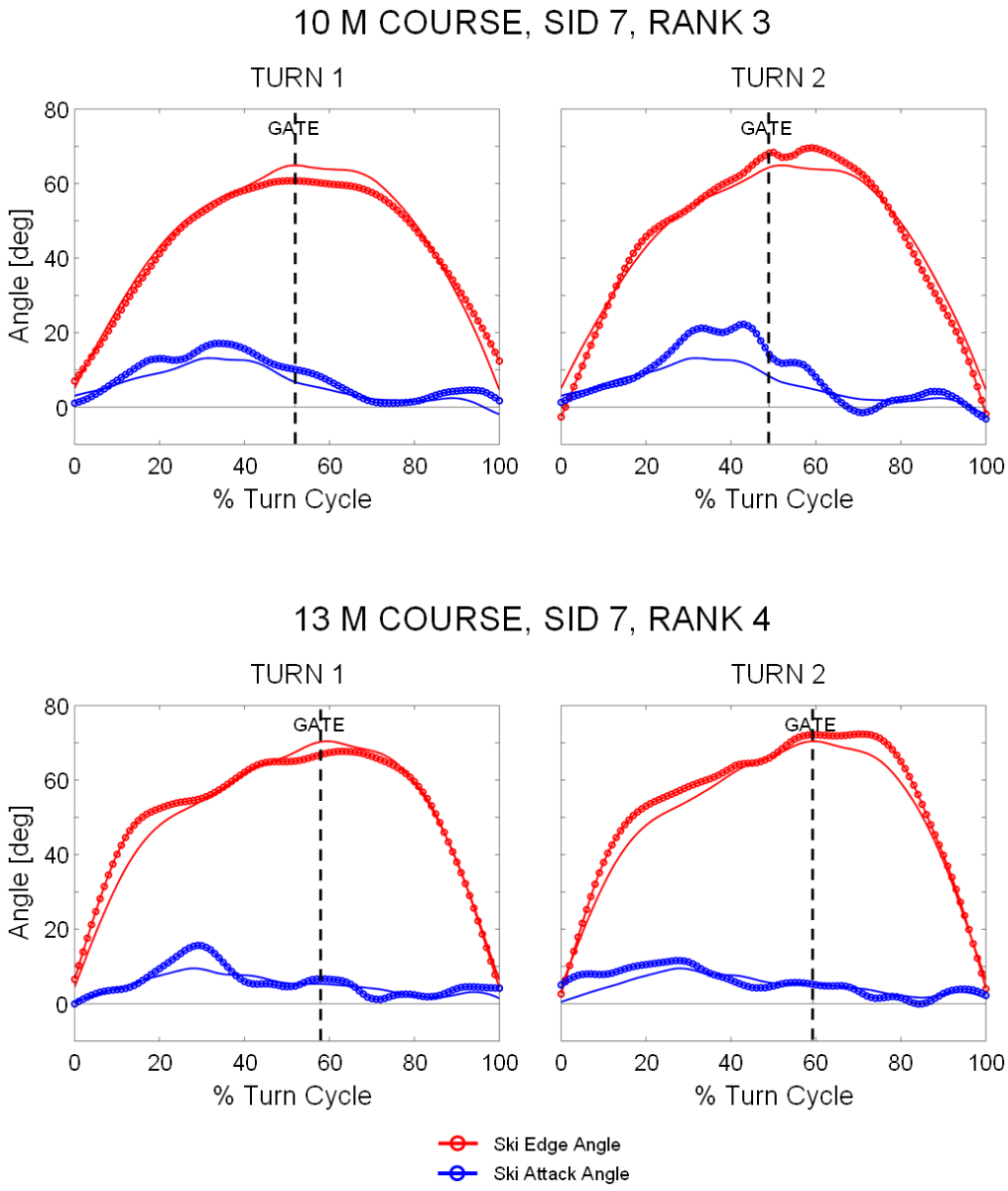


FIGURE J.3. Outside ski edge and attack angle for subject 7 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

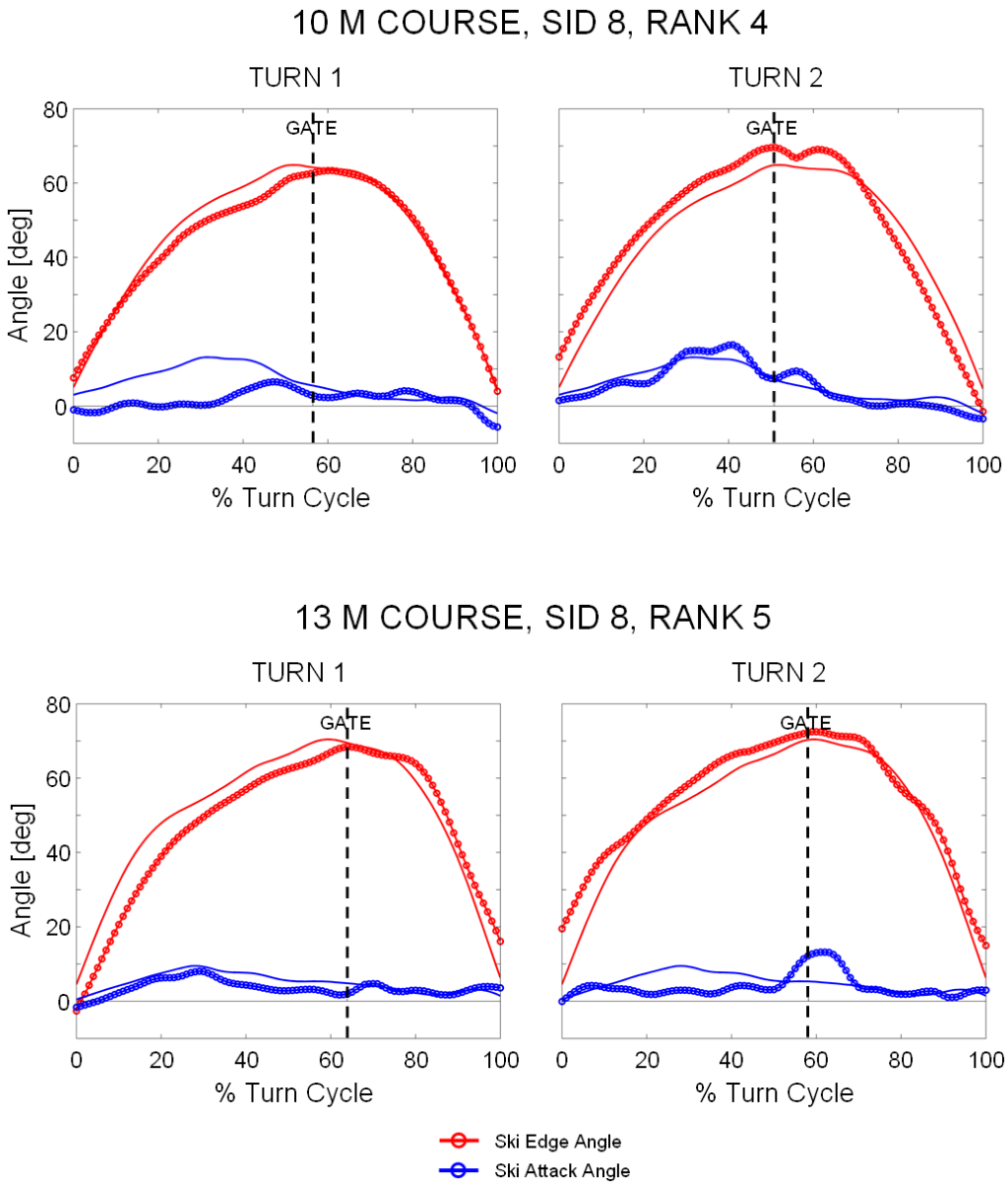


FIGURE J.4. Center of mass attack angle for subject 8 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

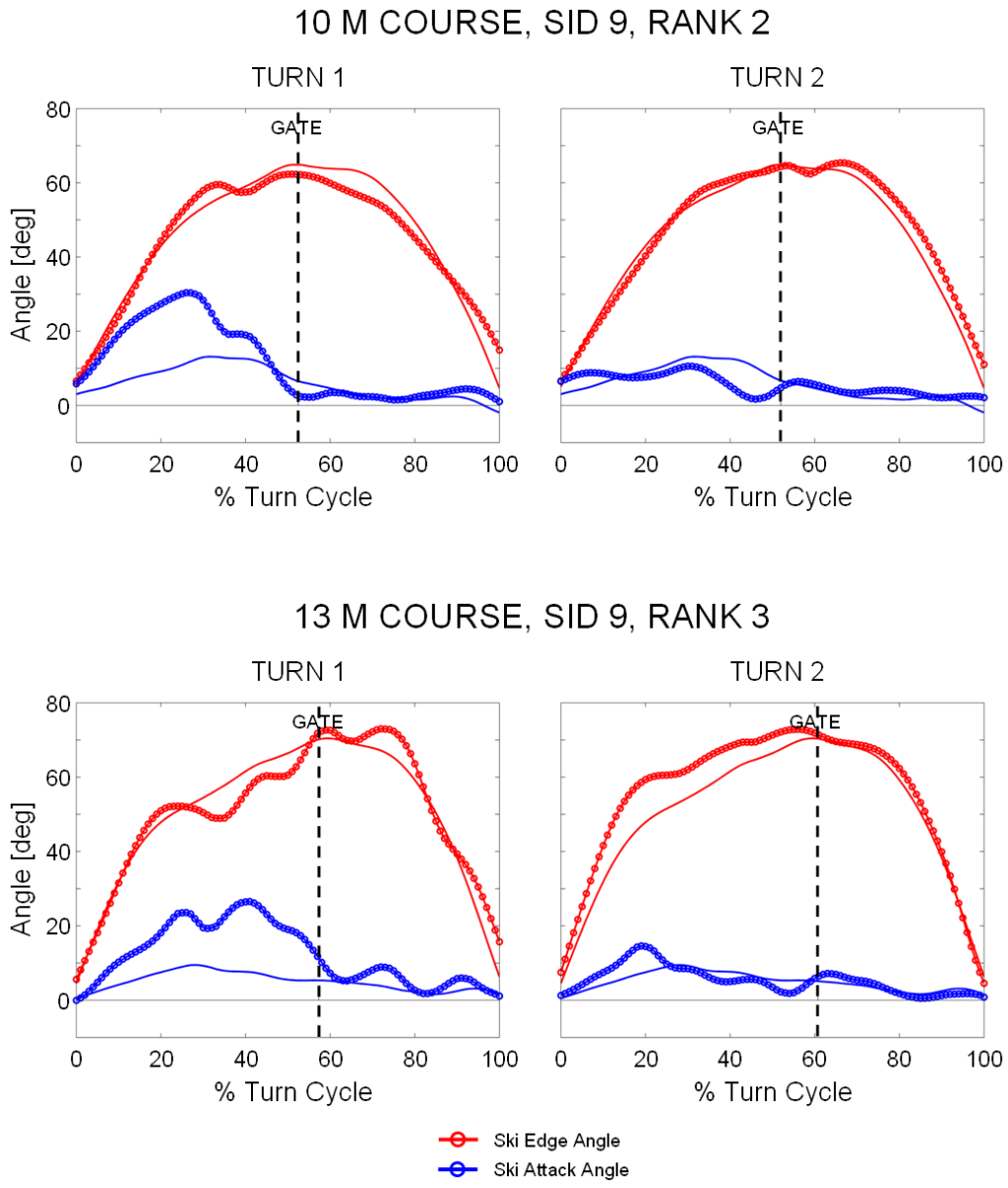


FIGURE J.5. Center of mass attack angle for subject 9 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

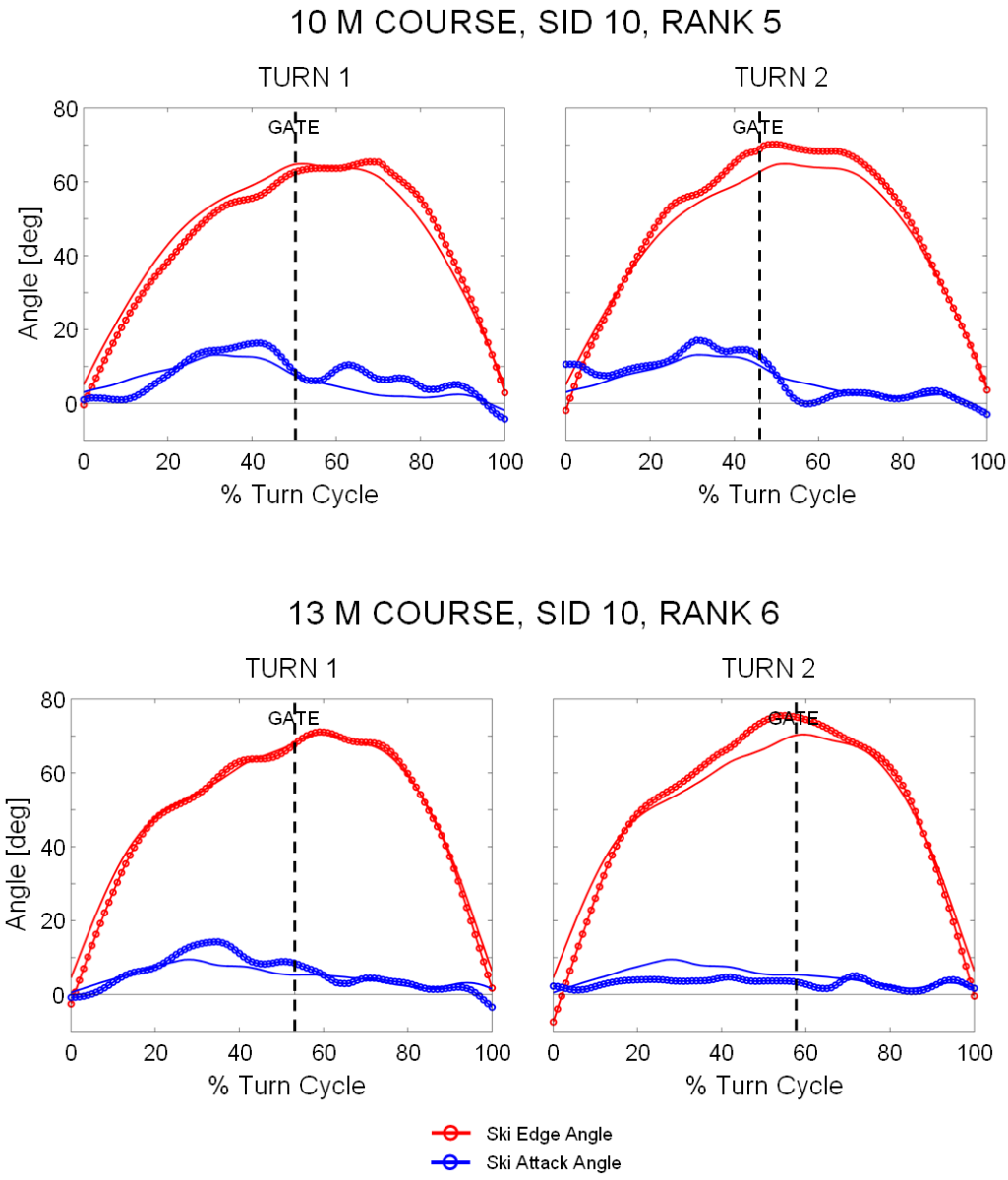


FIGURE J.6. Center of mass attack angle for subject 10 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

APPENDIX K. Individual Skier Lateral Action Data

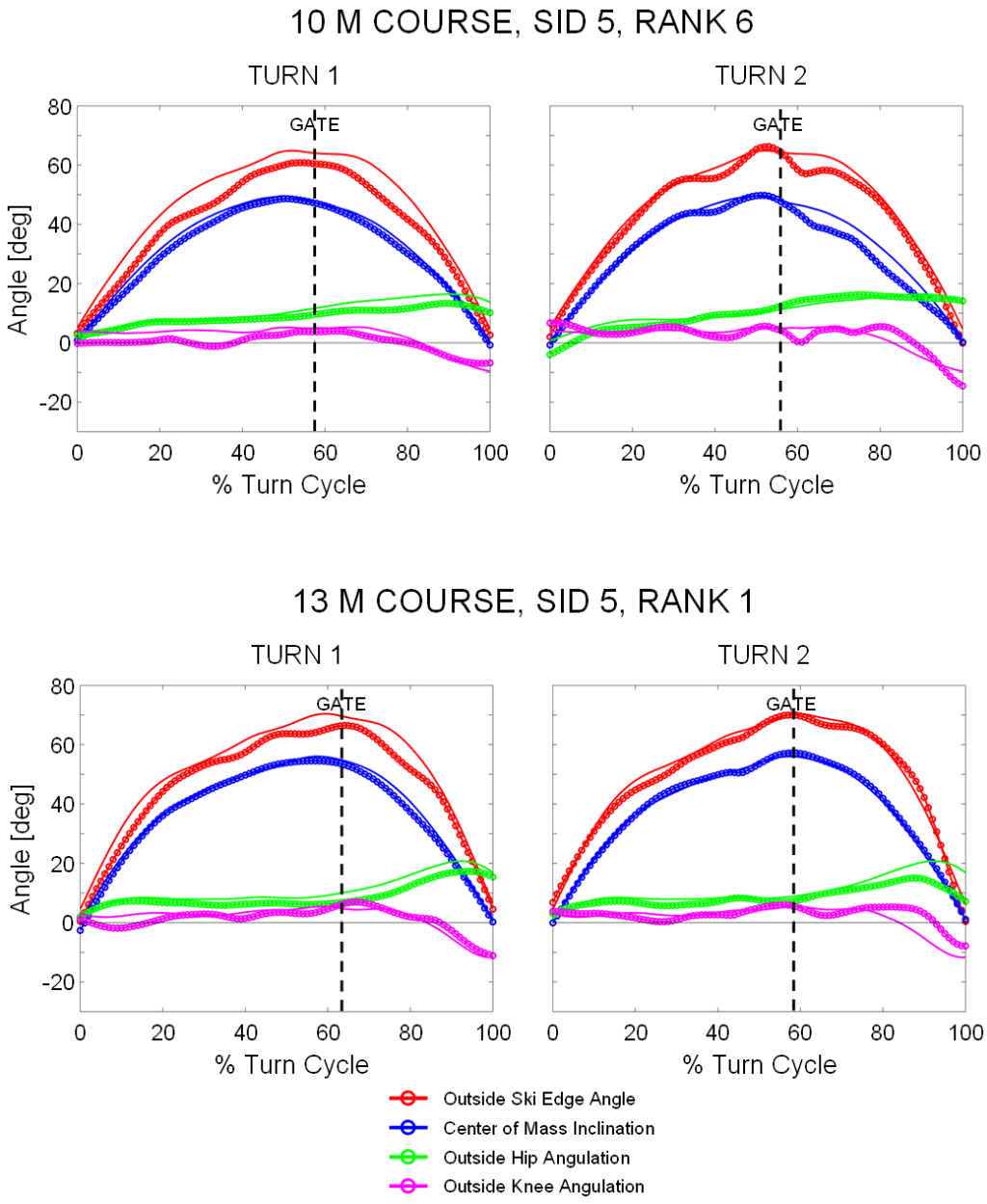


FIGURE K.1. Outside ski edge, center of mass inclination, outside hip angulation and outside knee angulation for subject 5 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

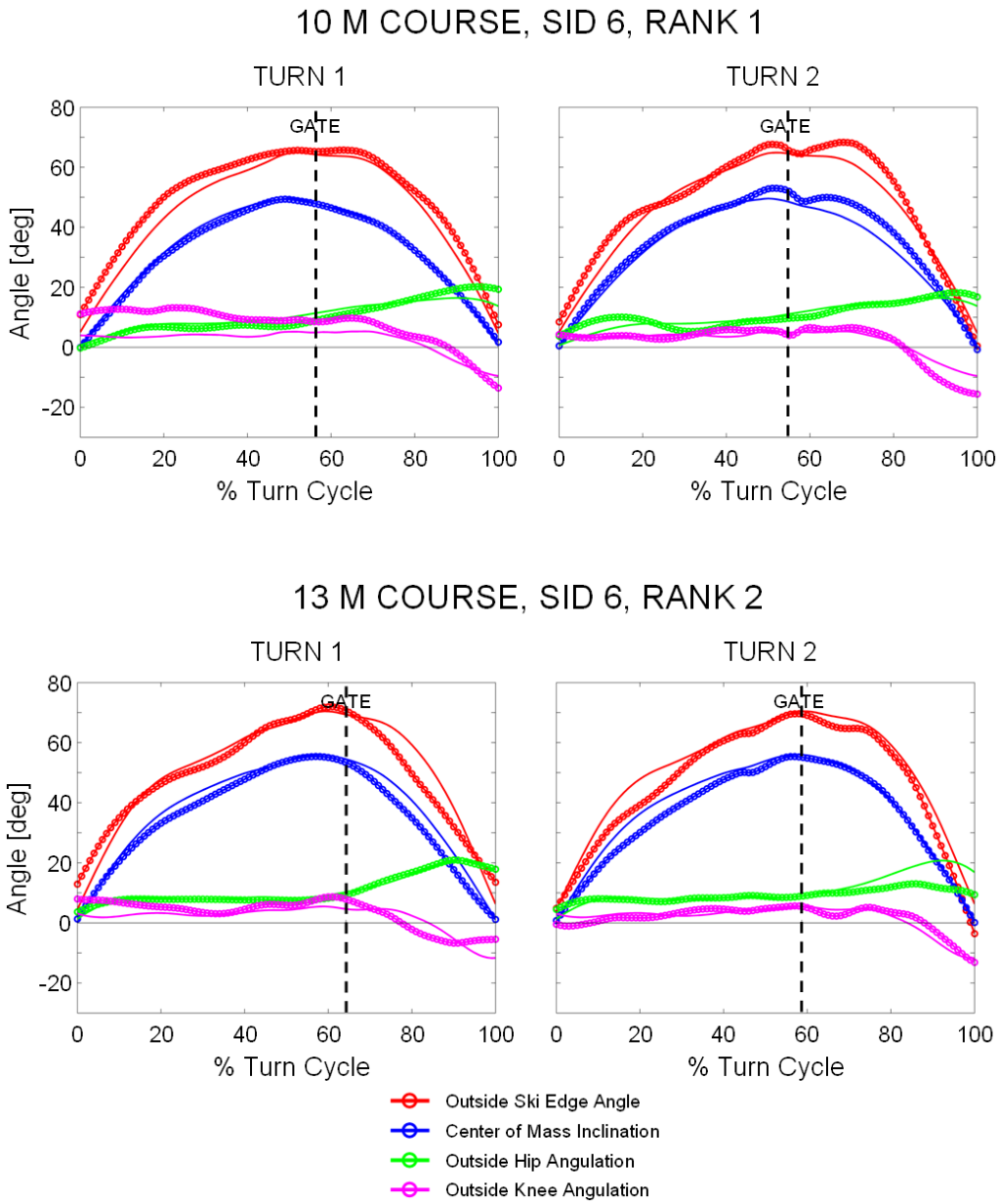


FIGURE K.2. Outside ski edge, center of mass inclination, outside hip angulation and outside knee angulation for subject 6 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

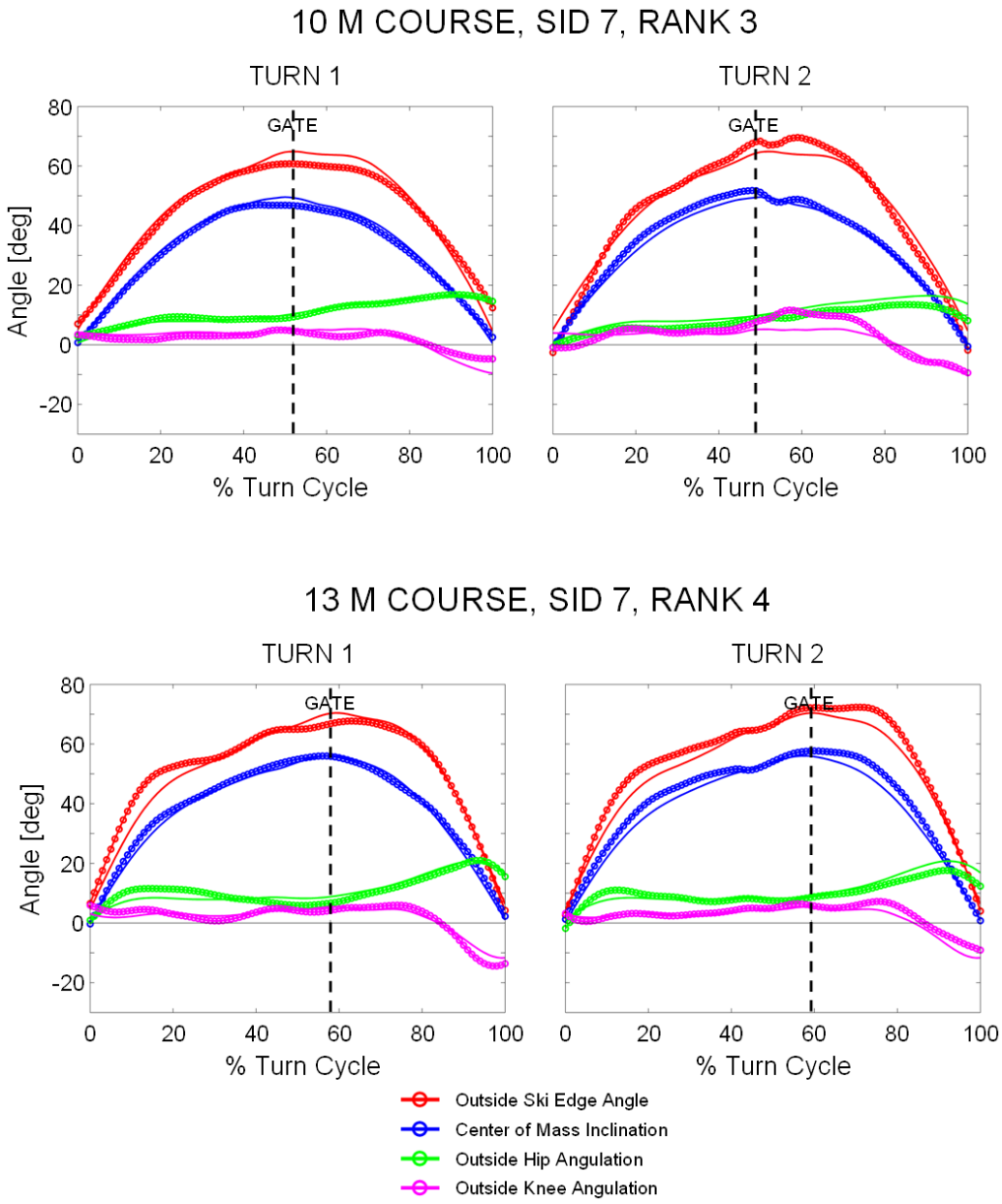


FIGURE K.3. Outside ski edge, center of mass inclination, outside hip angulation and outside knee angulation for subject 7 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

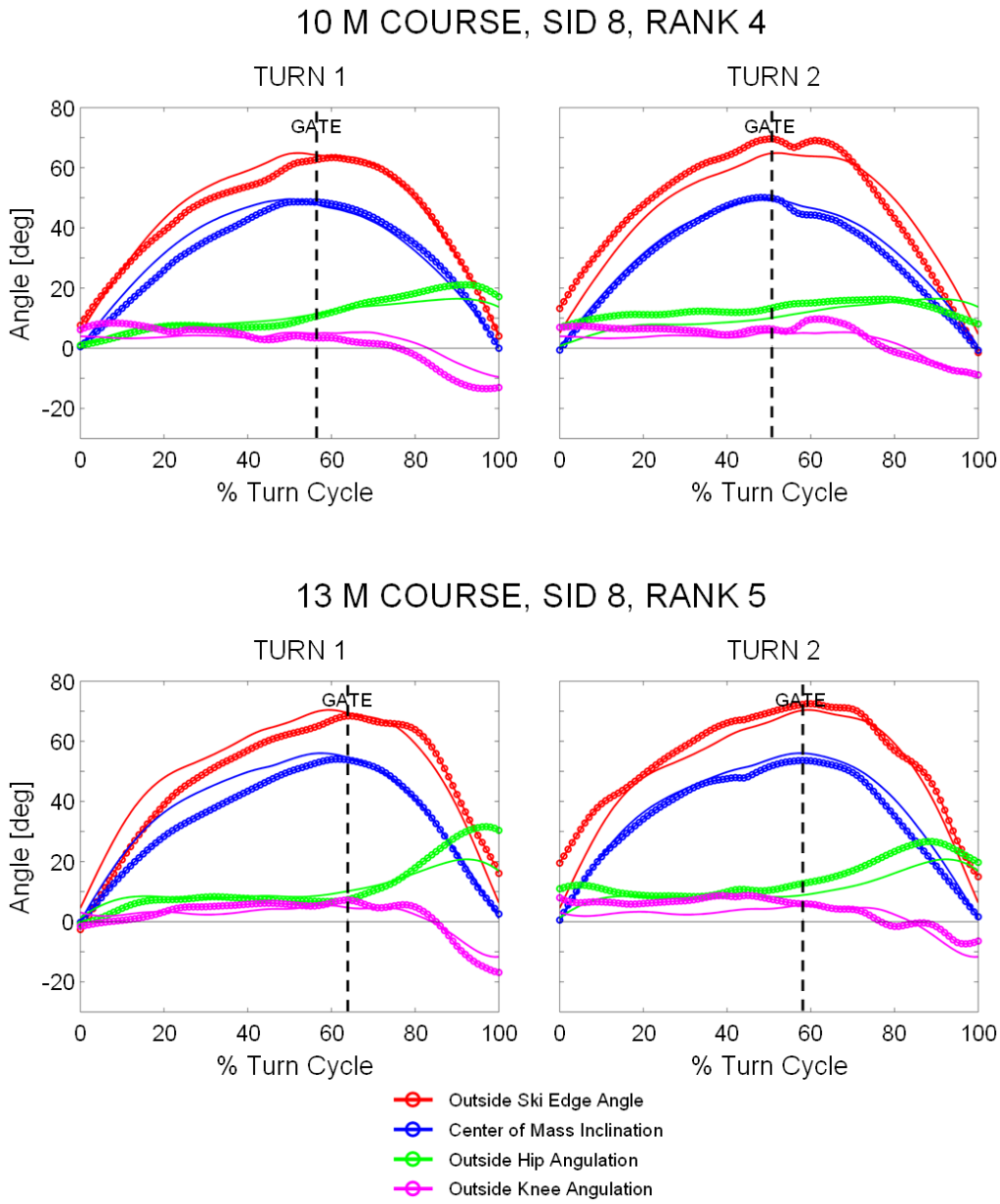


FIGURE K.4. Outside ski edge, center of mass inclination, outside hip angulation and outside knee angulation for subject 8 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

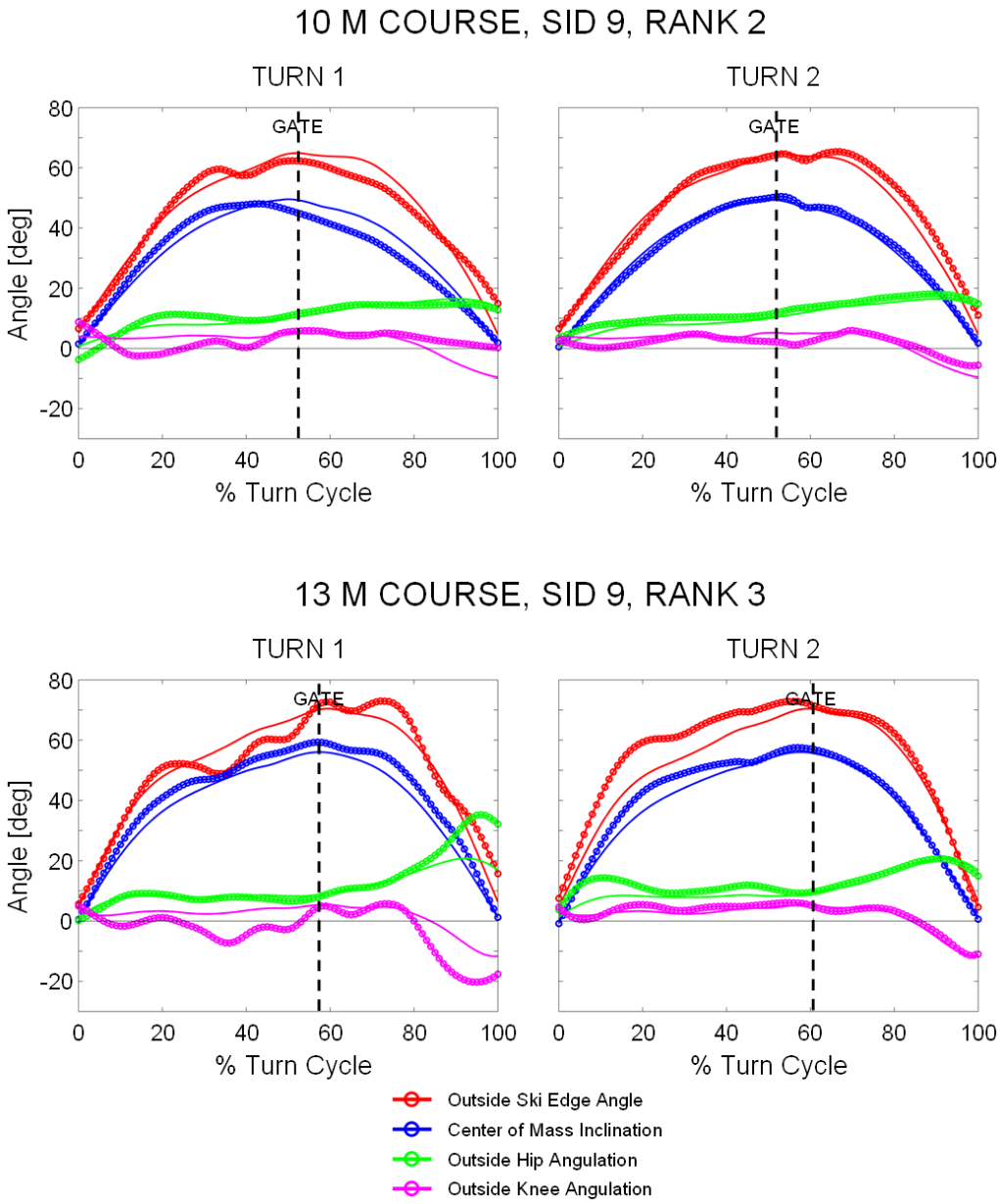


FIGURE K.5. Outside ski edge, center of mass inclination, outside hip angulation and outside knee angulation for subject 9 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

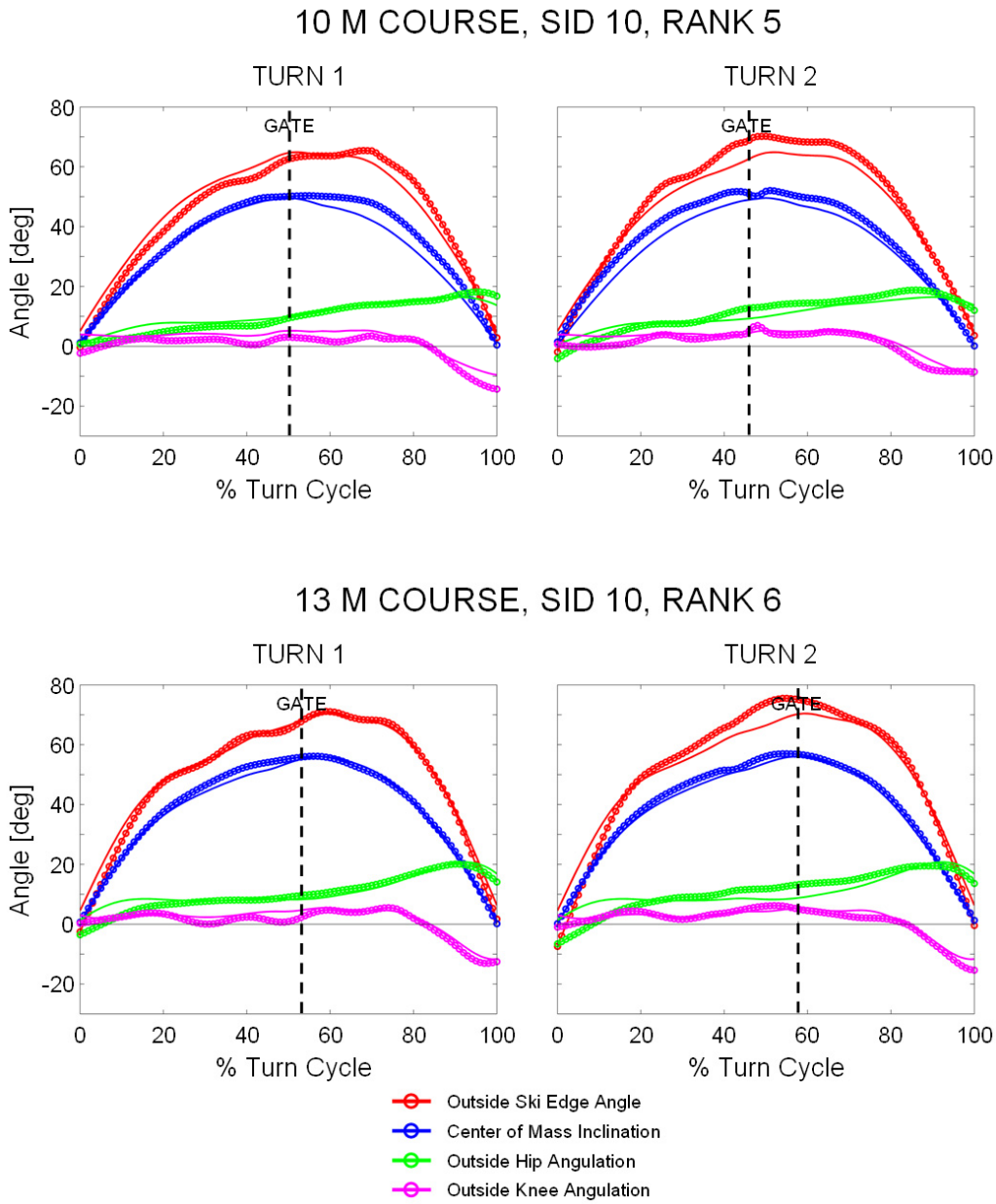


FIGURE K.6. Outside ski edge, center of mass inclination, outside hip angulation and outside knee angulation for subject 10 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

APPENDIX L. Individual Skier Veritcal Action Data

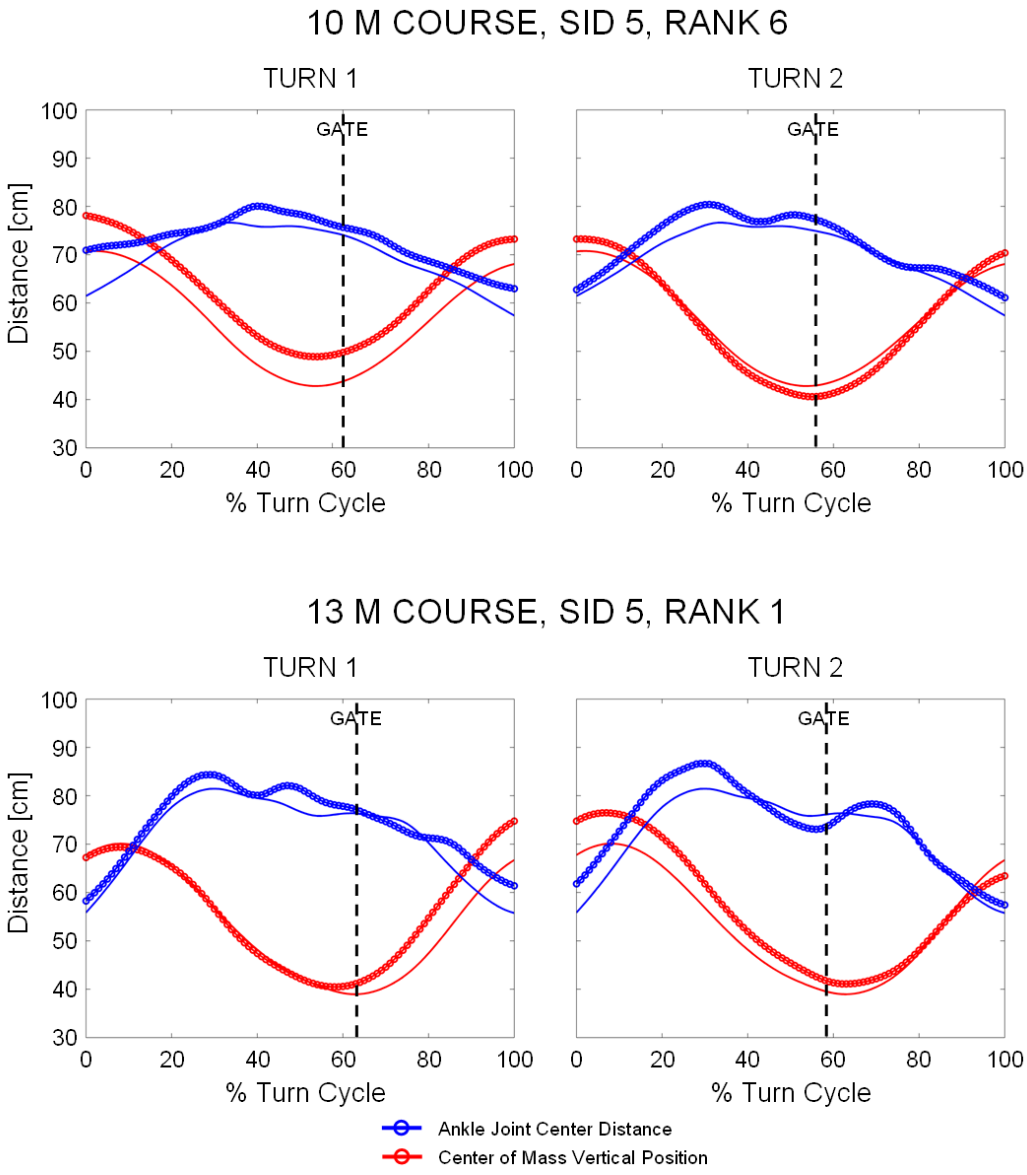


FIGURE L.1. Ankle joint center distance and center of mass vertical position for subject 5 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

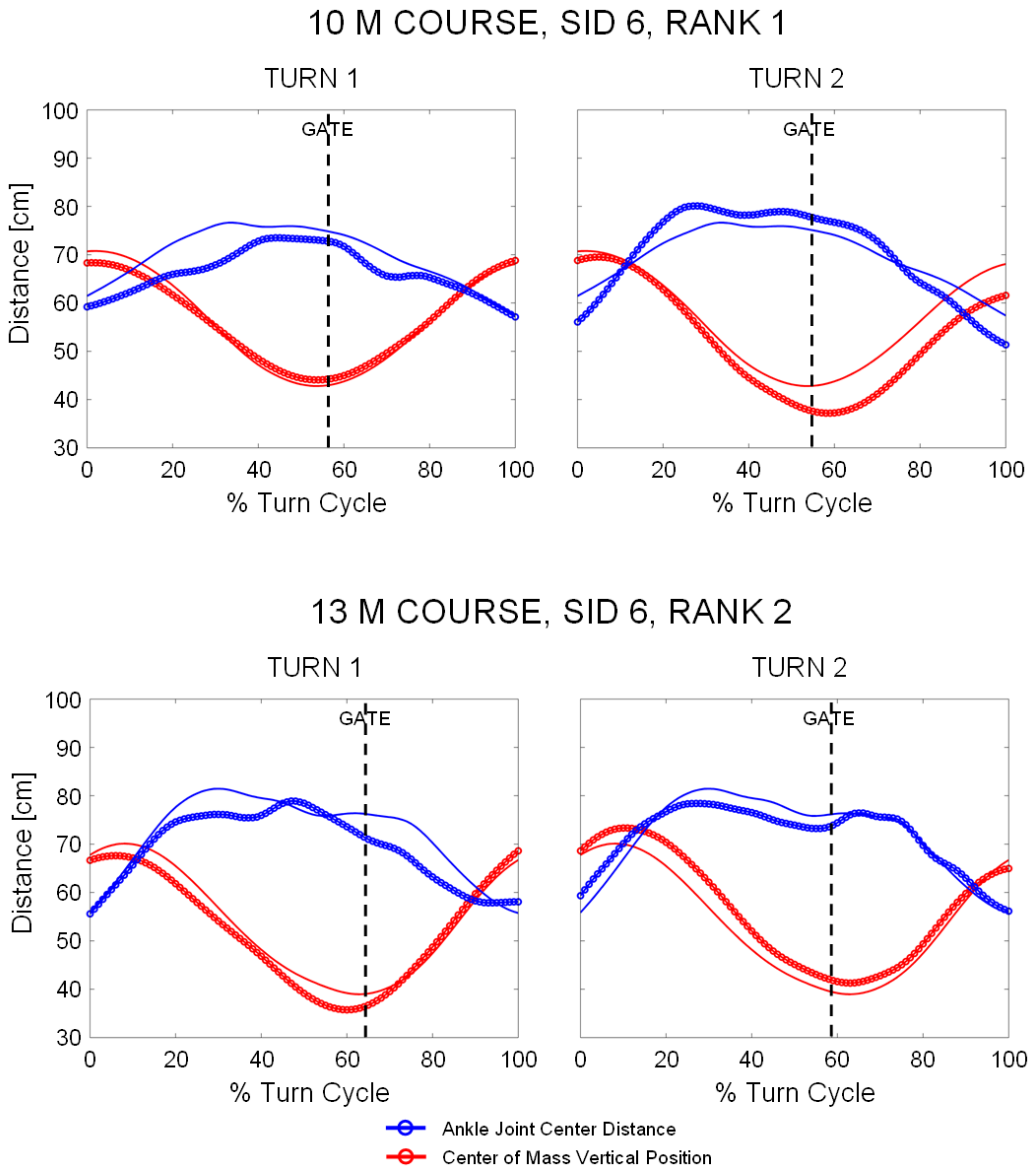


FIGURE L.2. Ankle joint center distance and center of mass vertical position for subject 6 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

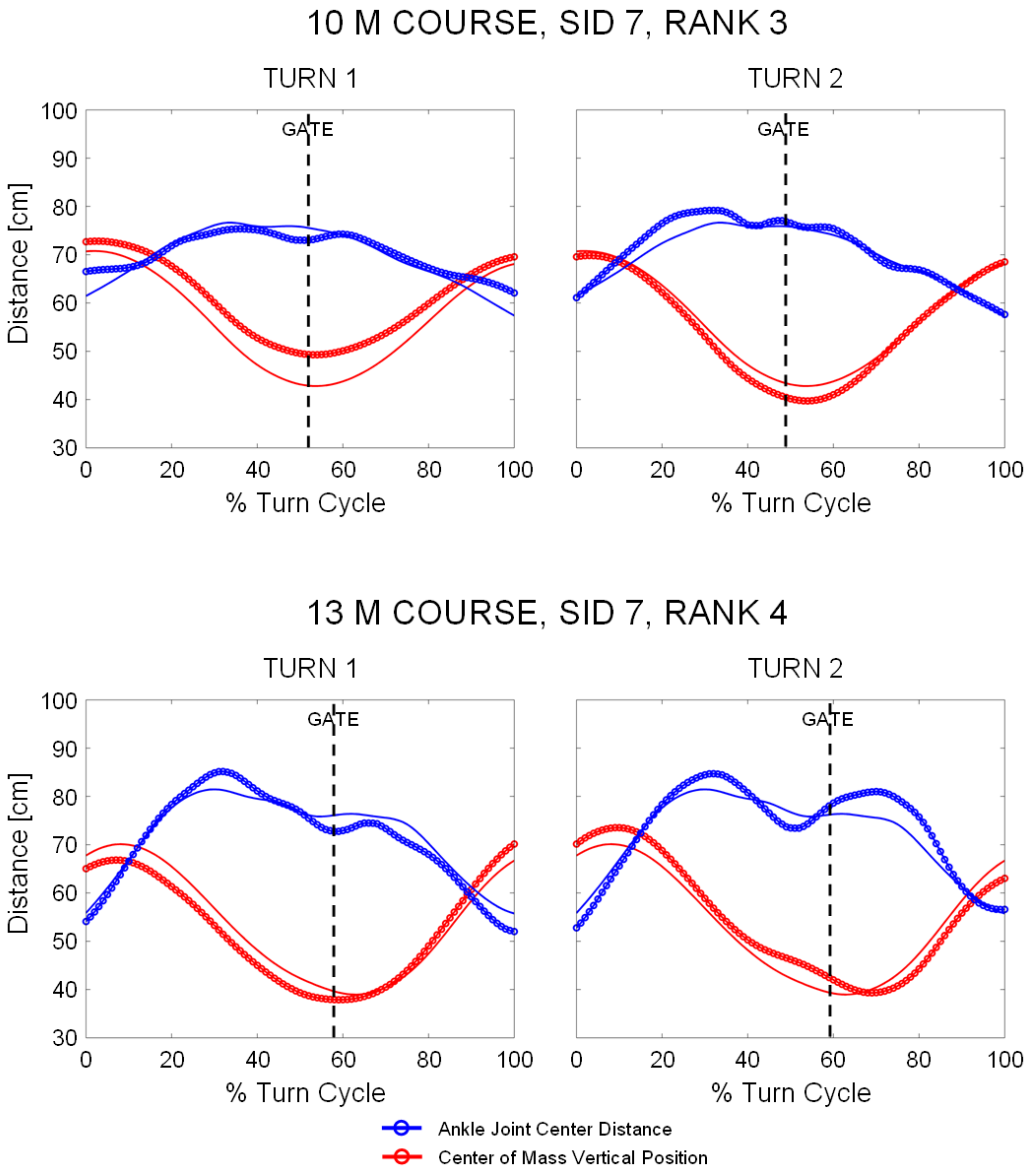


FIGURE L.3. Ankle joint center distance and center of mass vertical position for subject 7 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

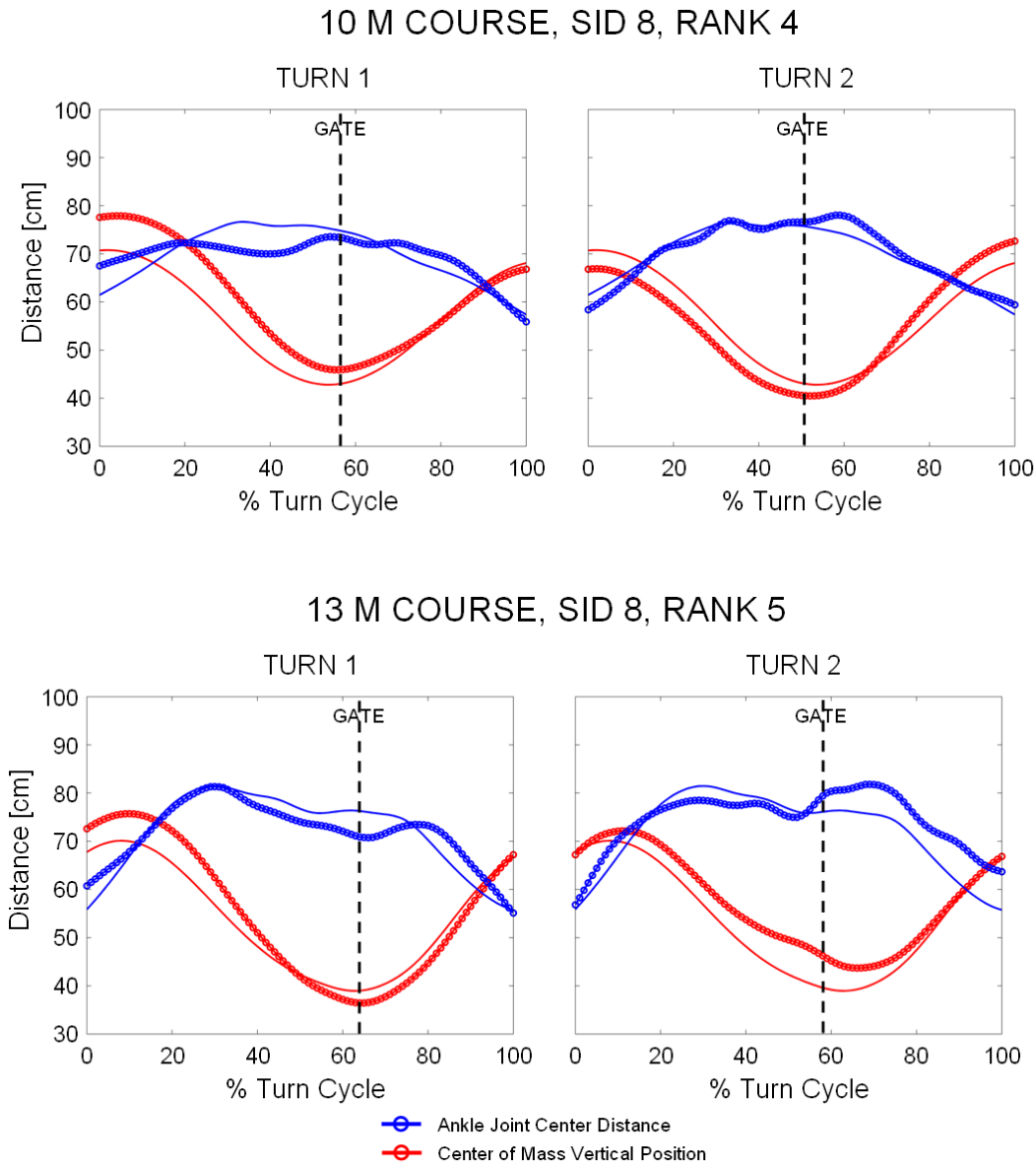


FIGURE L.4. Ankle joint center distance and center of mass vertical position for subject 8 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

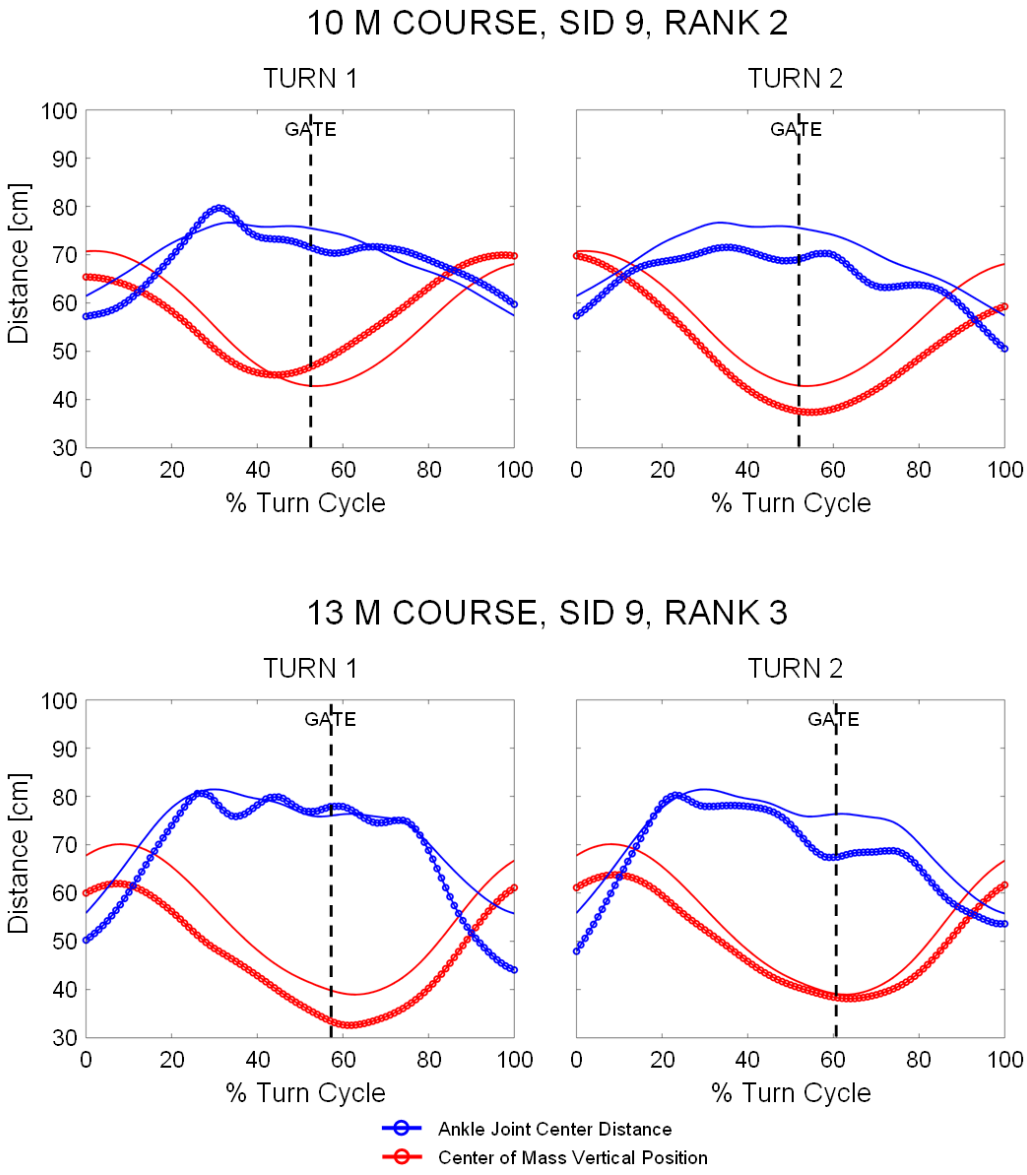


FIGURE L.5. Ankle joint center distance and center of mass vertical position for subject 9 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

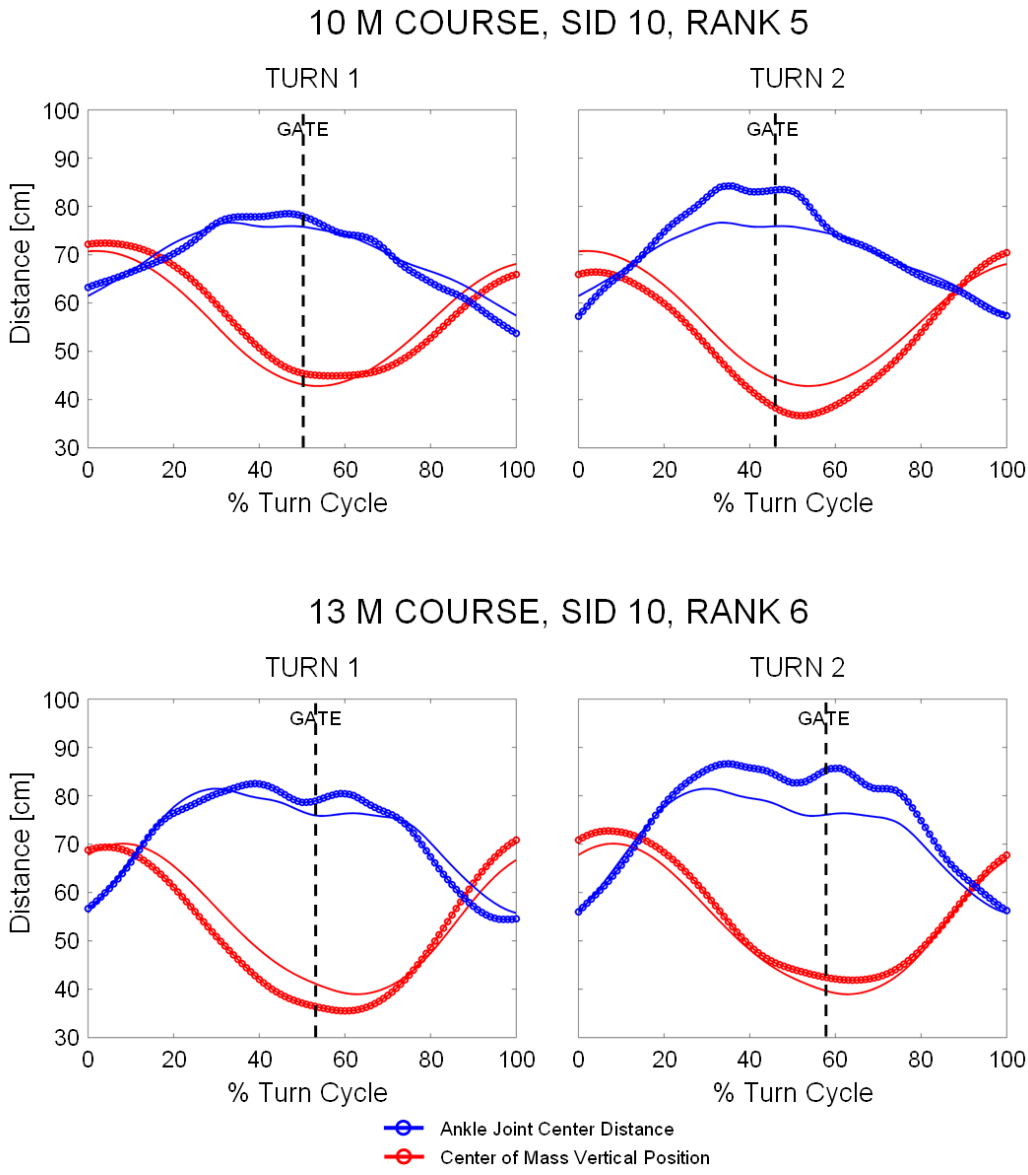


FIGURE L.6. Ankle joint center distance and center of mass vertical position for subject 10 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

APPENDIX M. Individual Skier Fore/Aft Action Data

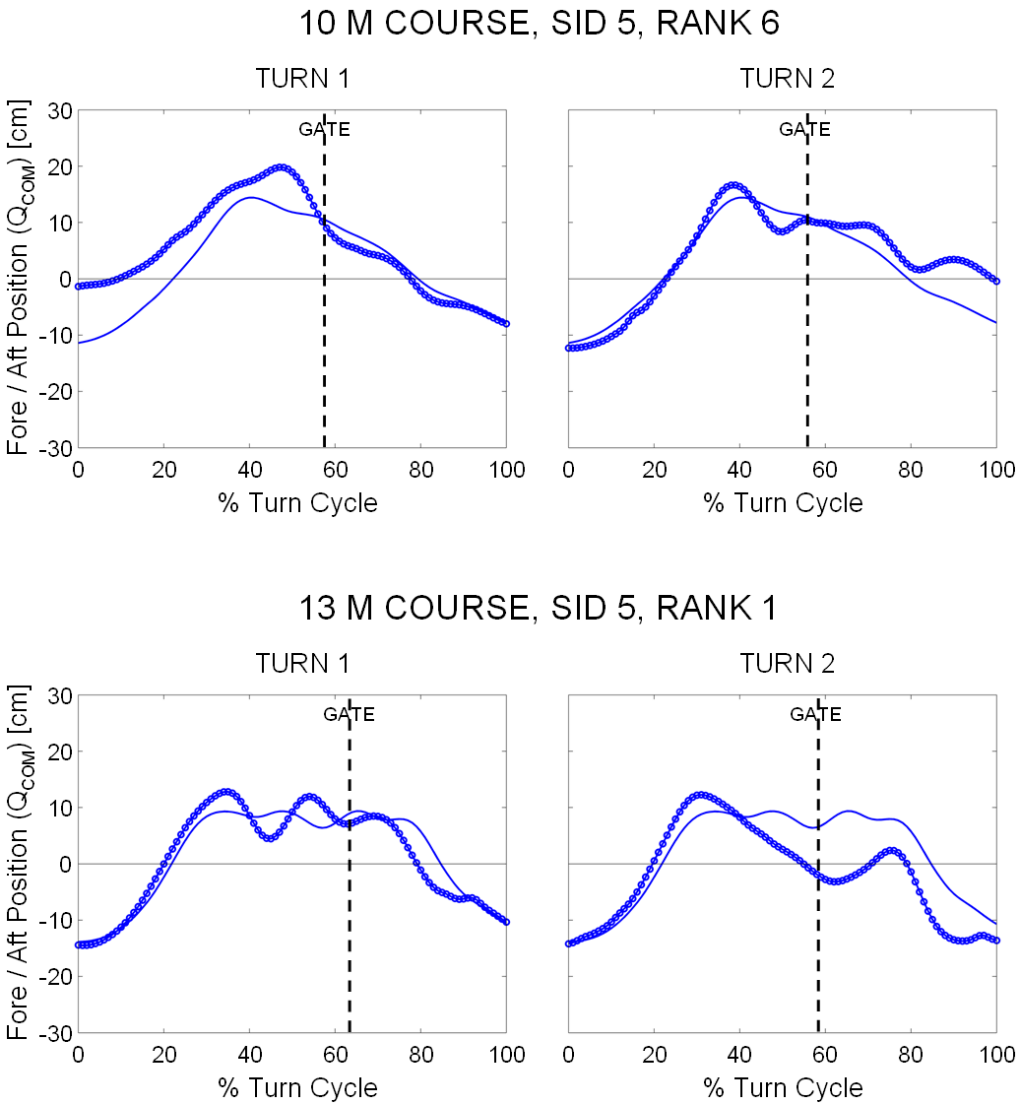


FIGURE M.1. Center of mass fore/aft position for subject 5 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

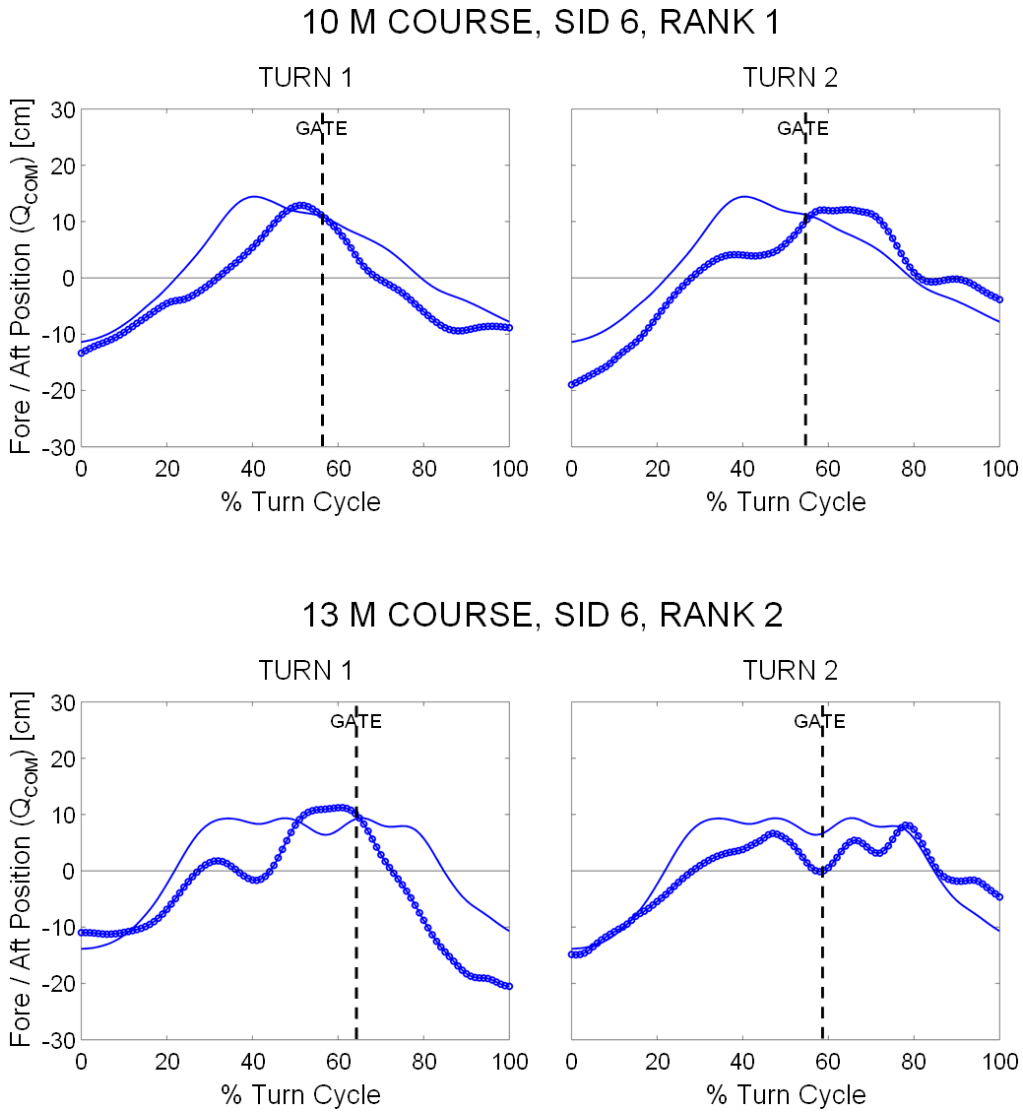


FIGURE M.2. Center of mass fore/aft position for subject 6 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

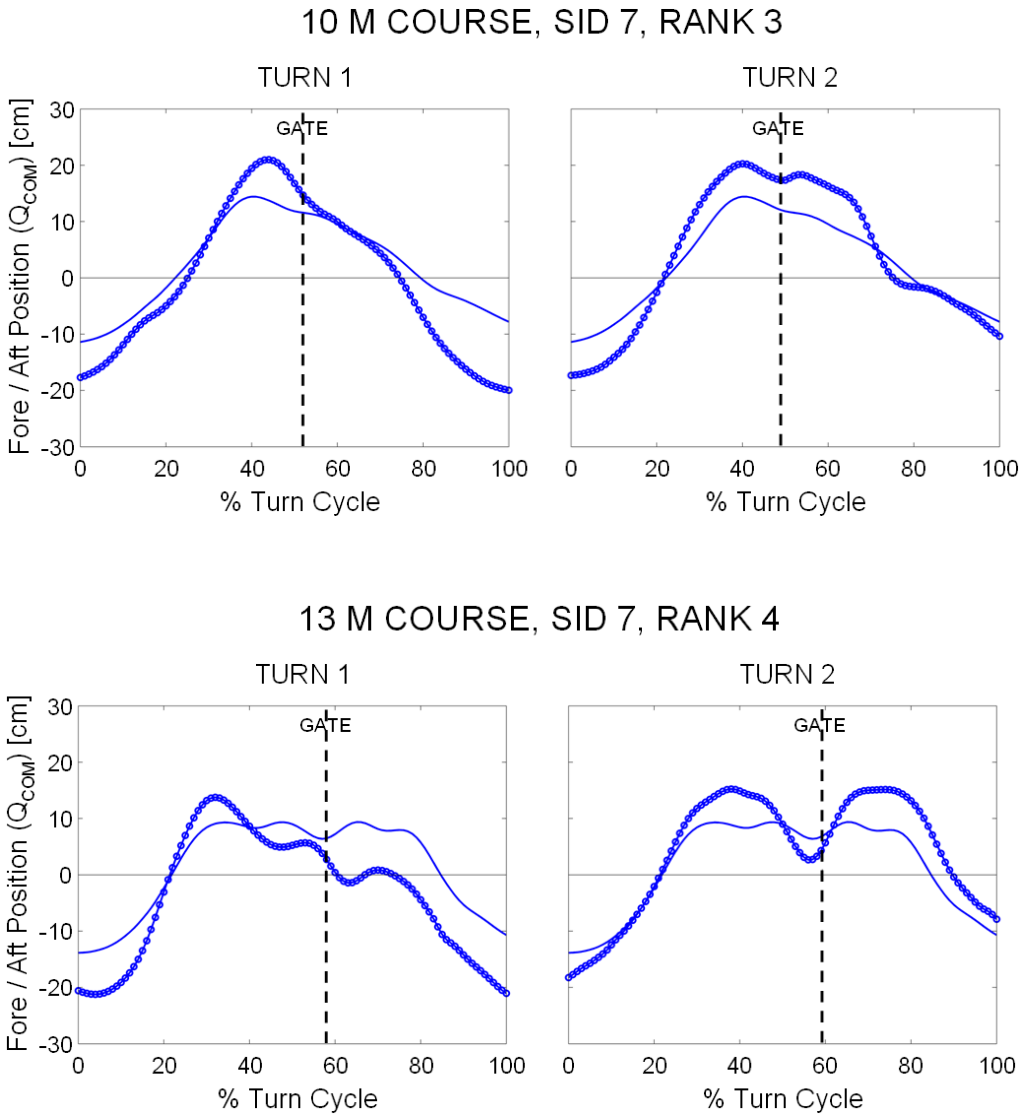


FIGURE M.3. Center of mass fore/aft position for subject 7 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

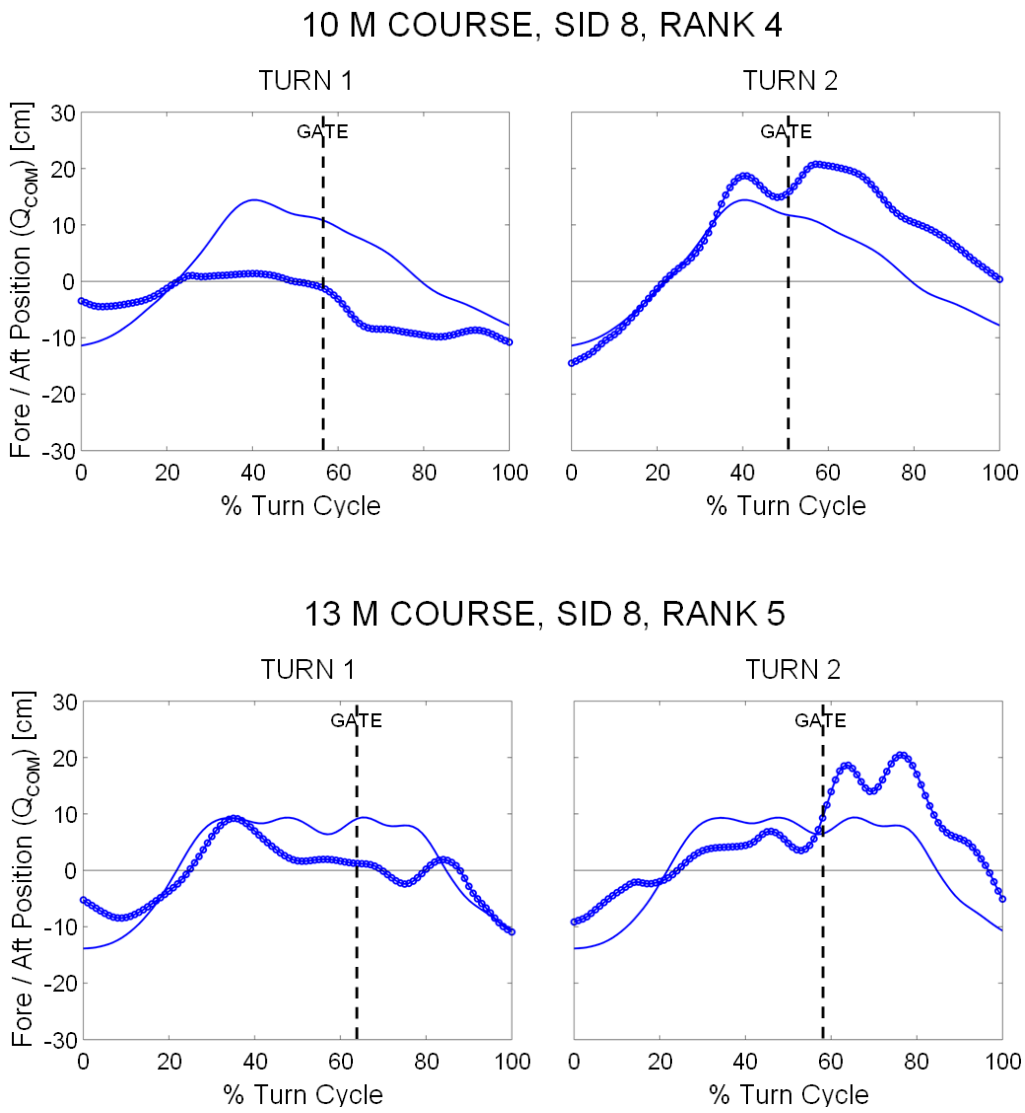


FIGURE M.4. Center of mass fore/aft position for subject 8 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

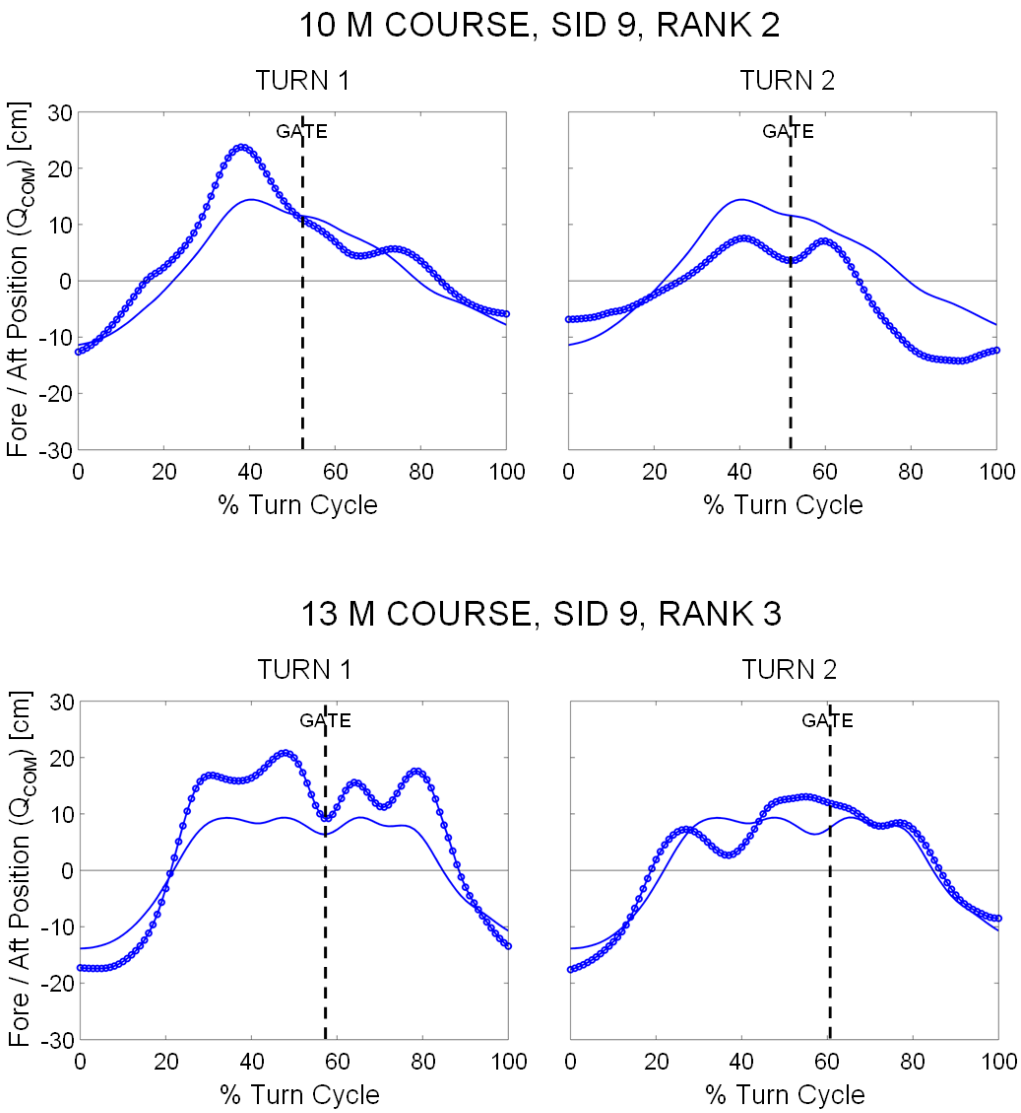


FIGURE M.5. Center of mass fore/aft position for subject 9 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

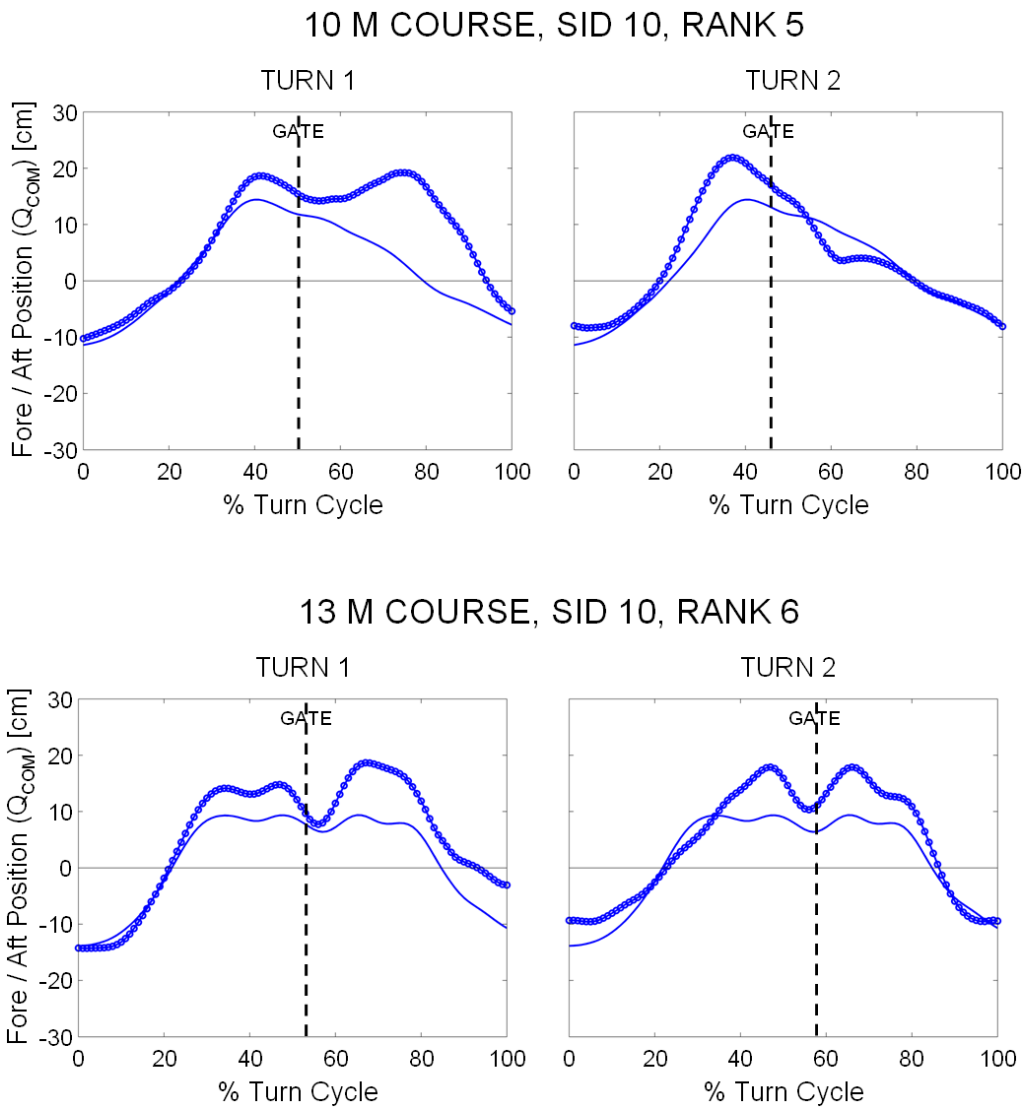


FIGURE M.6. Center of mass fore/aft position for subject 10 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

APPENDIX N. Individual External Force Power Data

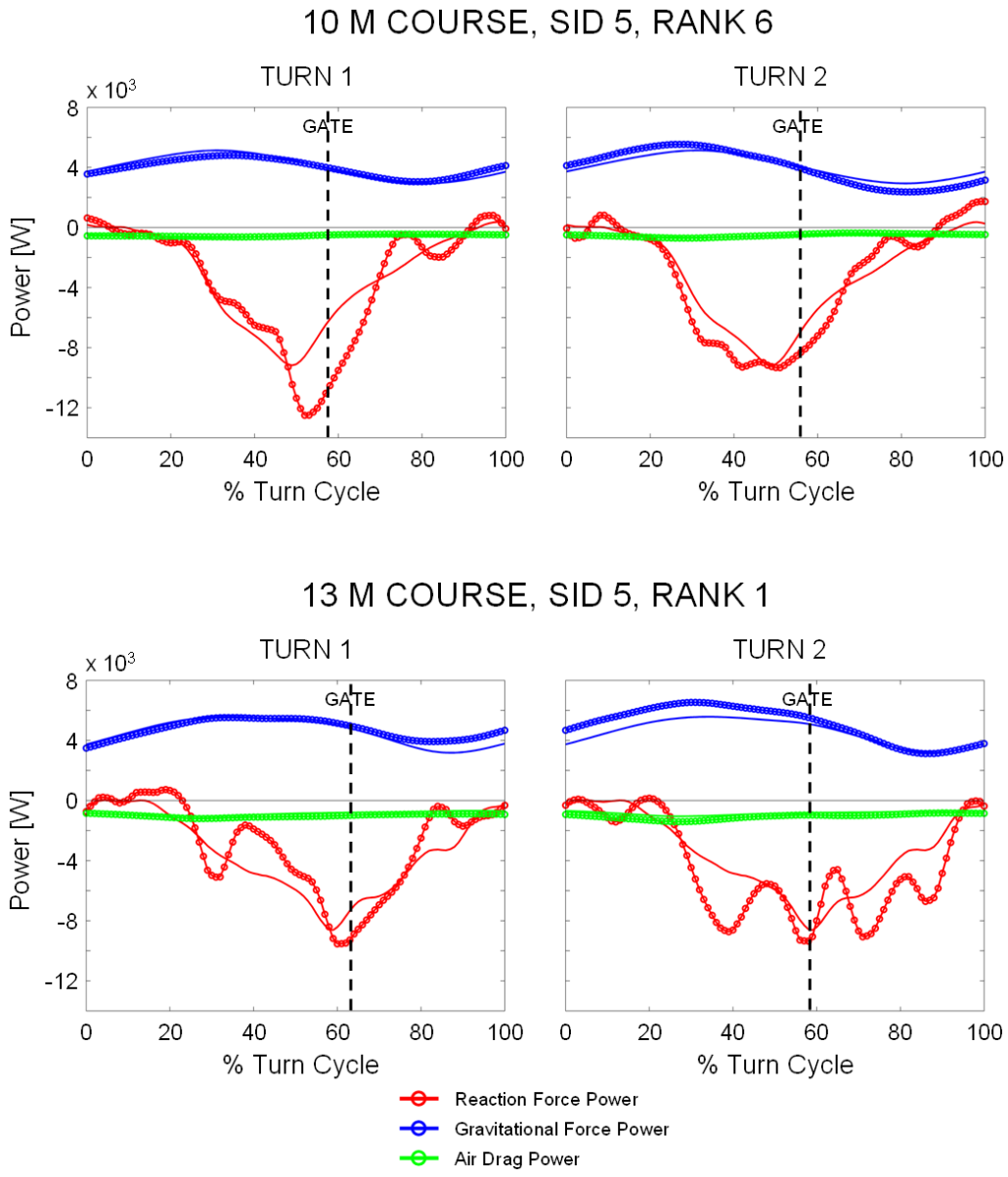


FIGURE N.1. External force power for subject 5 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

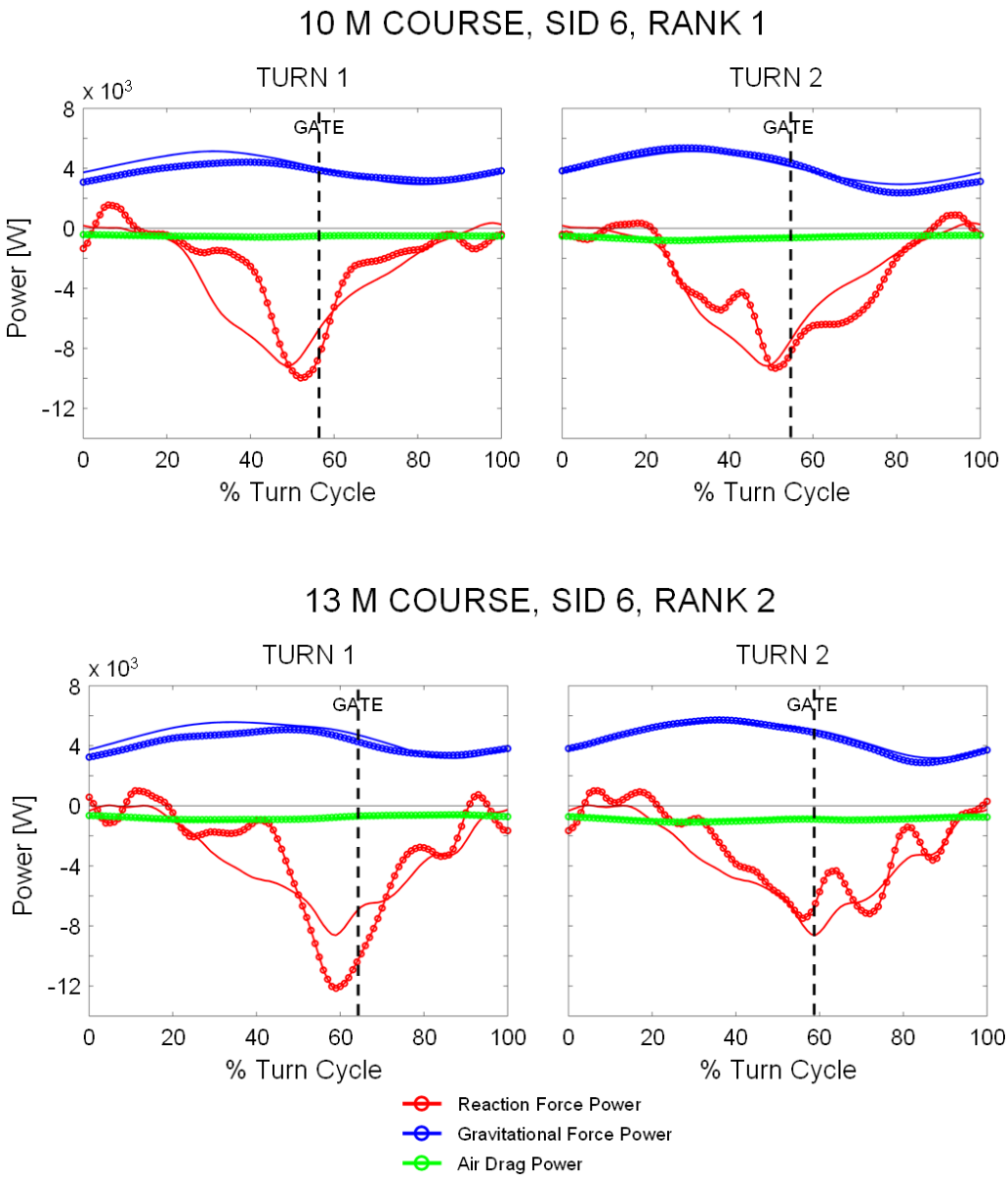


FIGURE N.2. External force power for subject 6 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

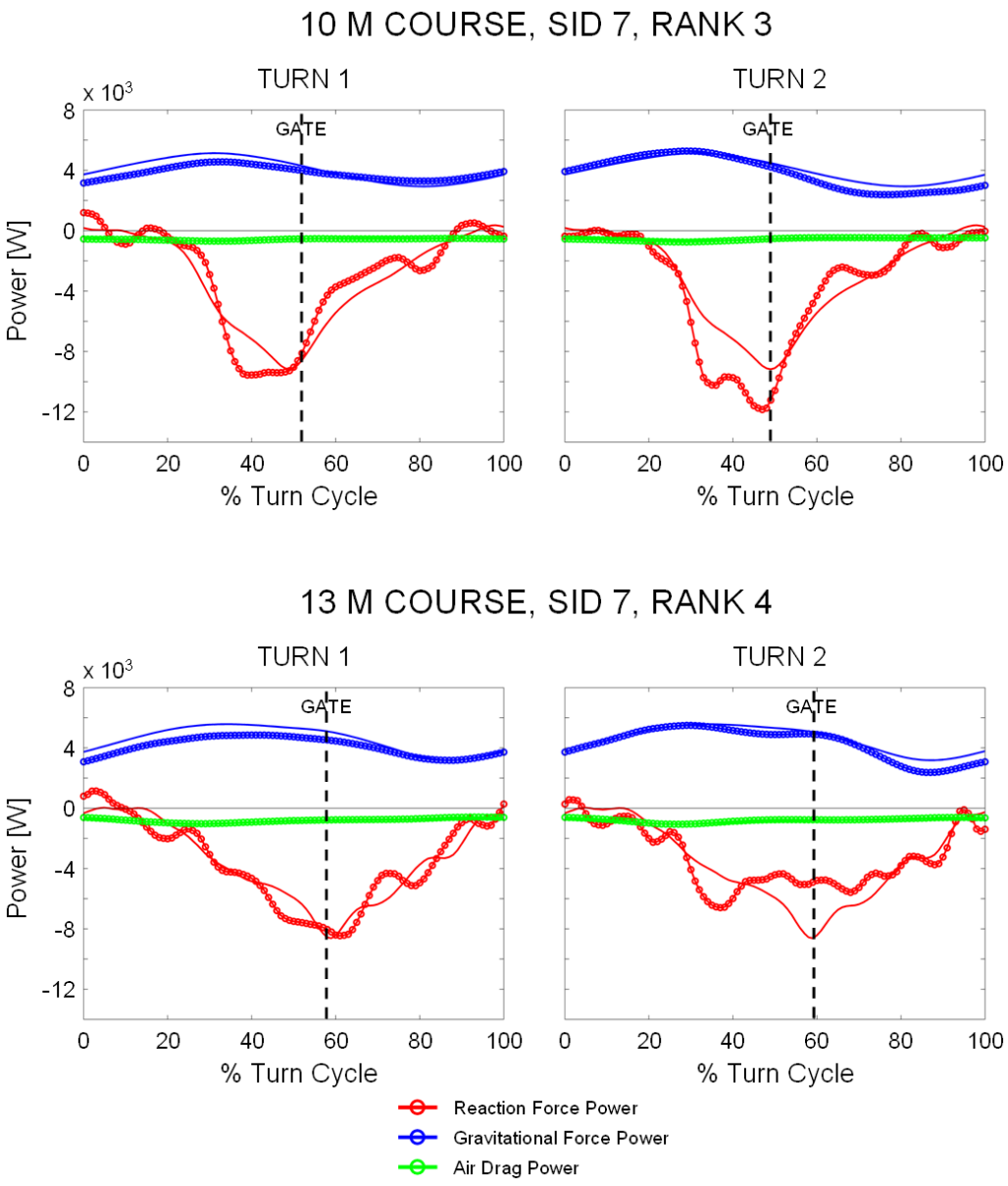


FIGURE N.3. External force power for subject 7 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

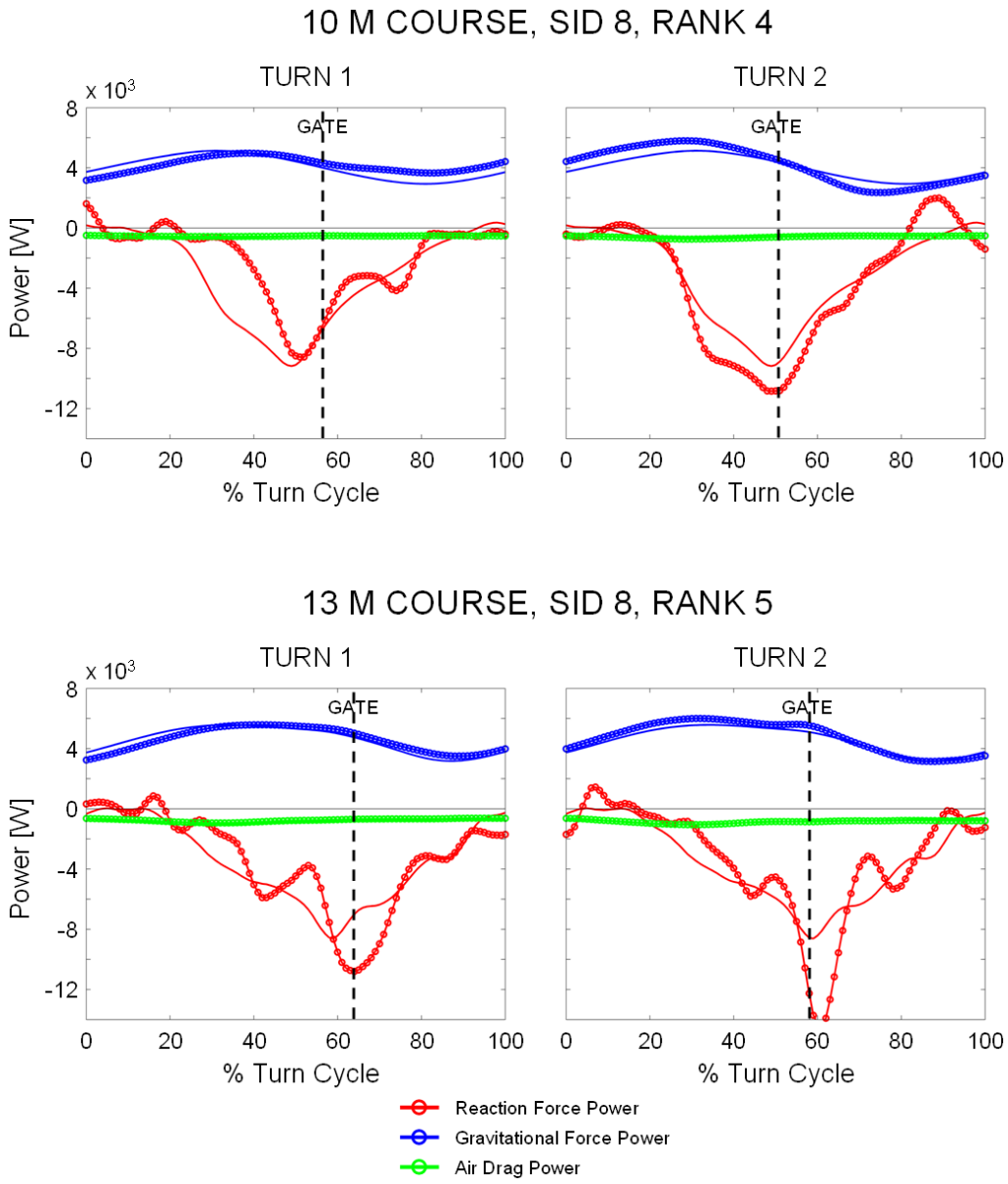


FIGURE N.4. External force power for subject 8 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

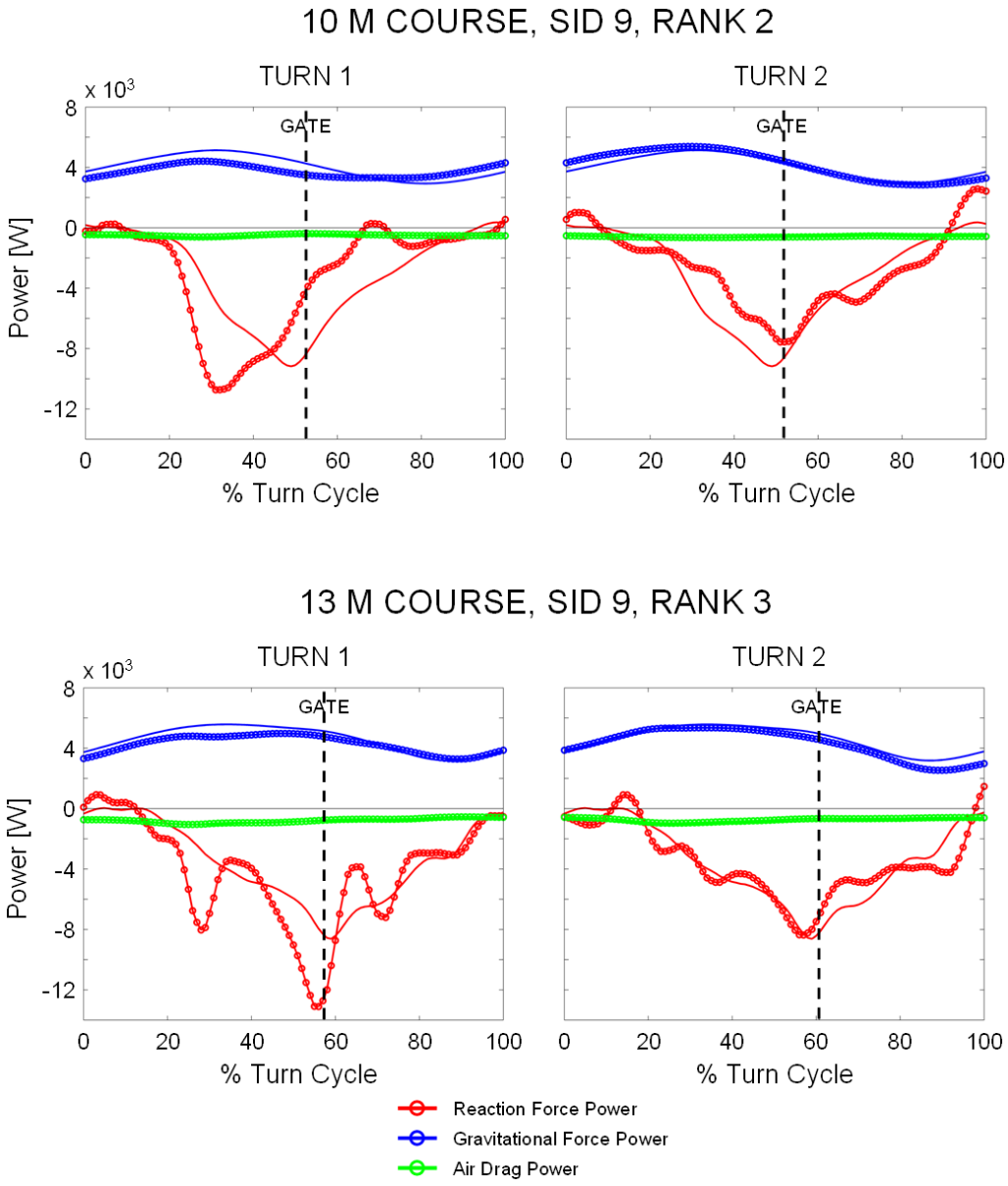


FIGURE N.5. External force power for subject 9 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

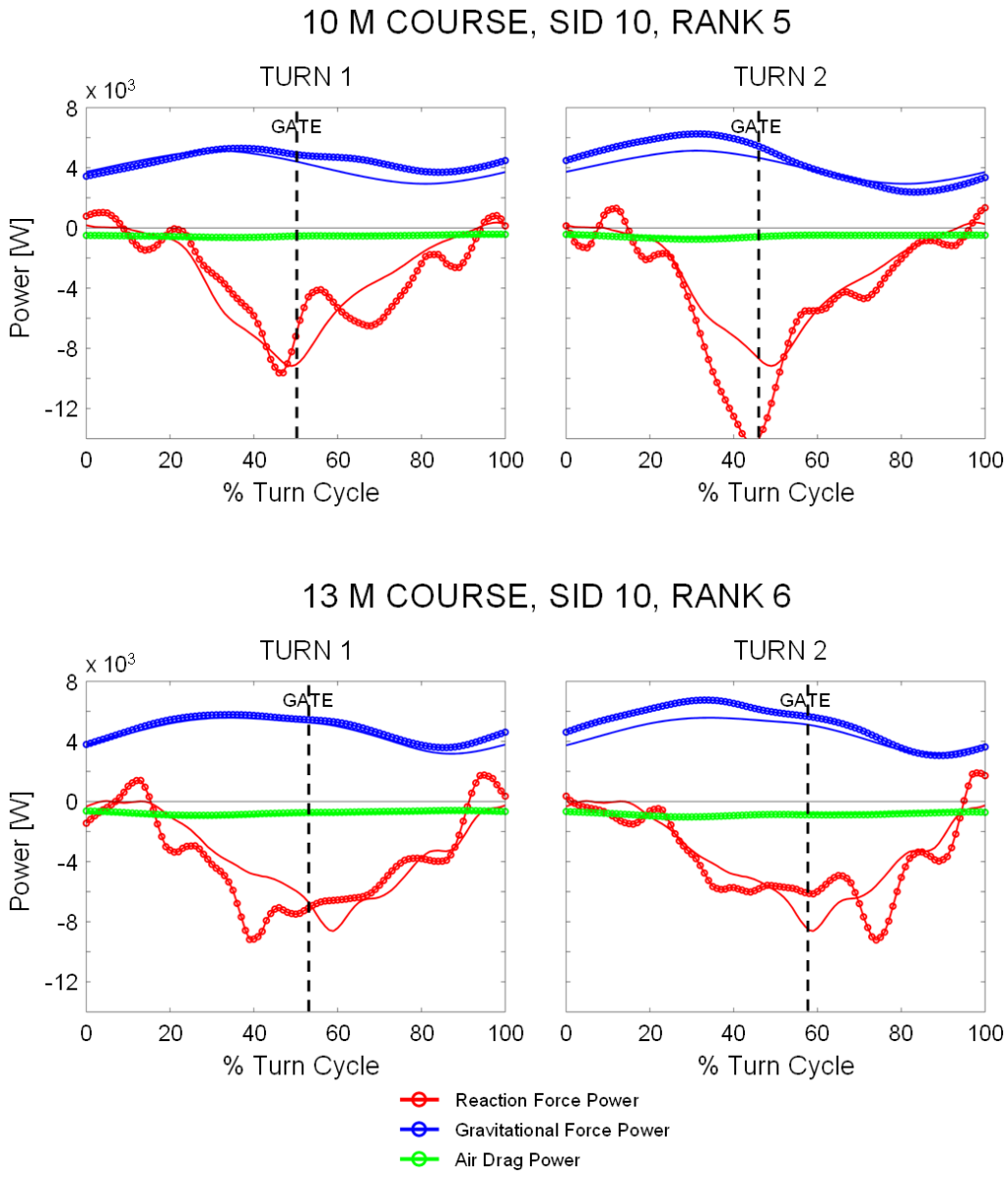


FIGURE N.6. External force power for subject 10 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

APPENDIX O. Individual Energy Dissipation Data

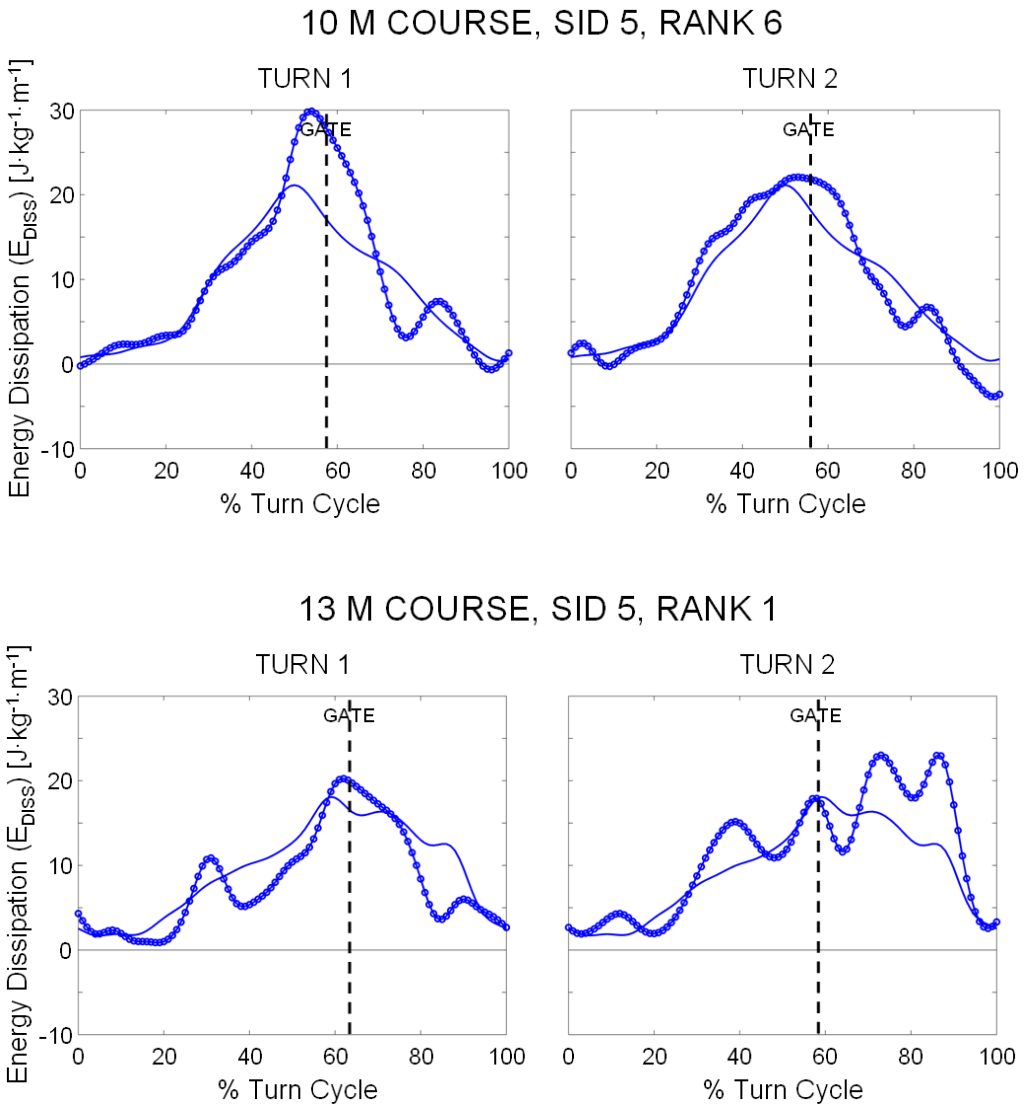


FIGURE O.1. Mechanical energy dissipation for subject 5 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

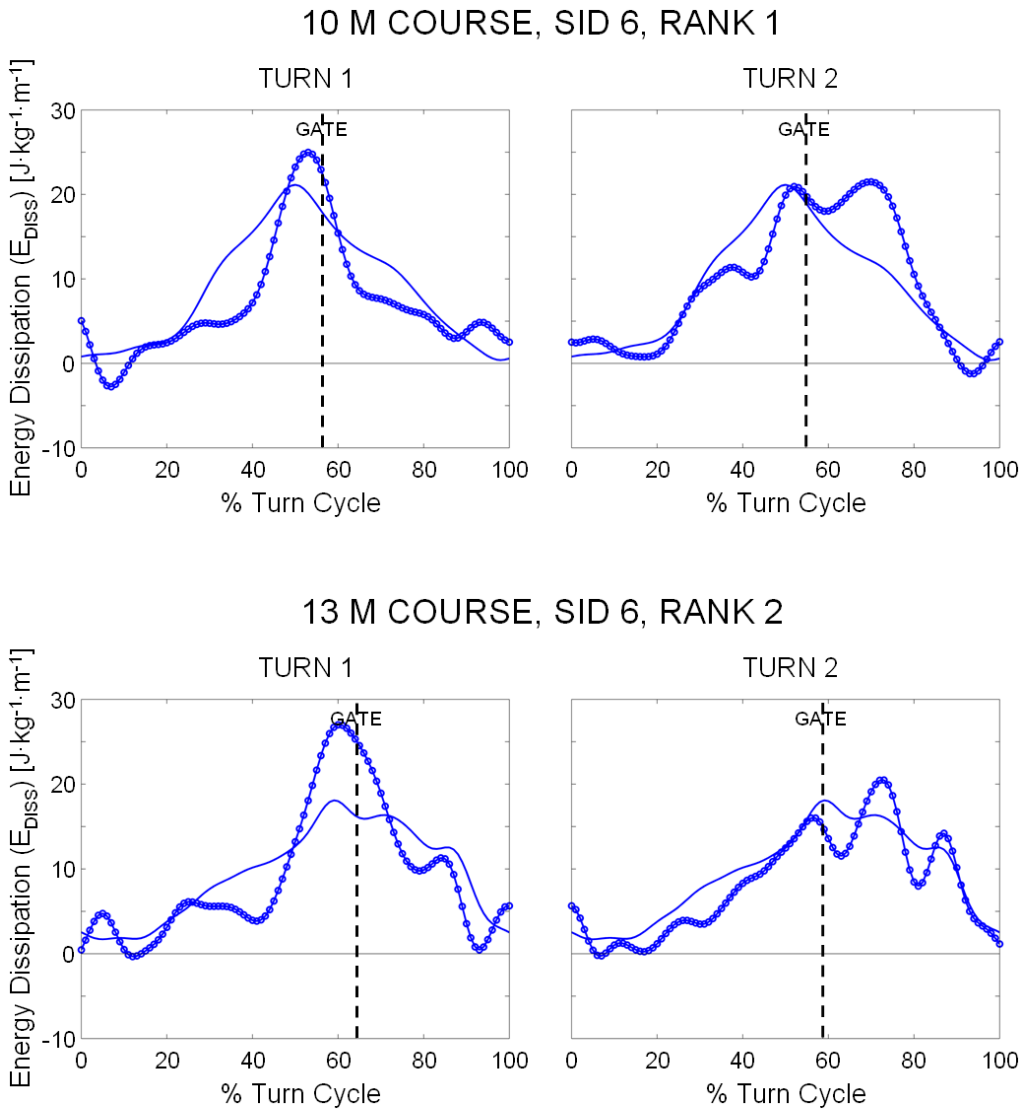


FIGURE O.2. Mechanical energy dissipation for subject 6 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

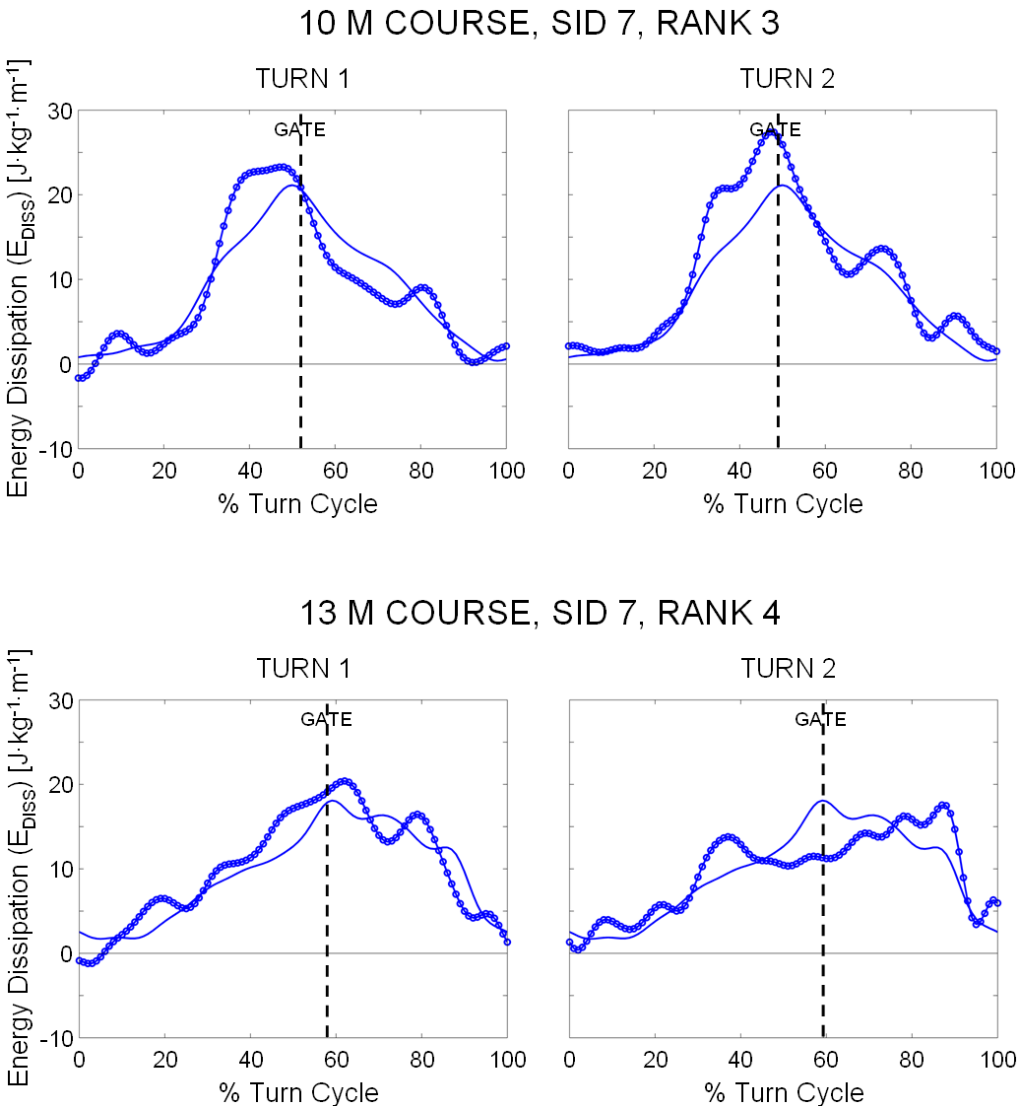


FIGURE O.3. Mechanical energy dissipation for subject 7 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

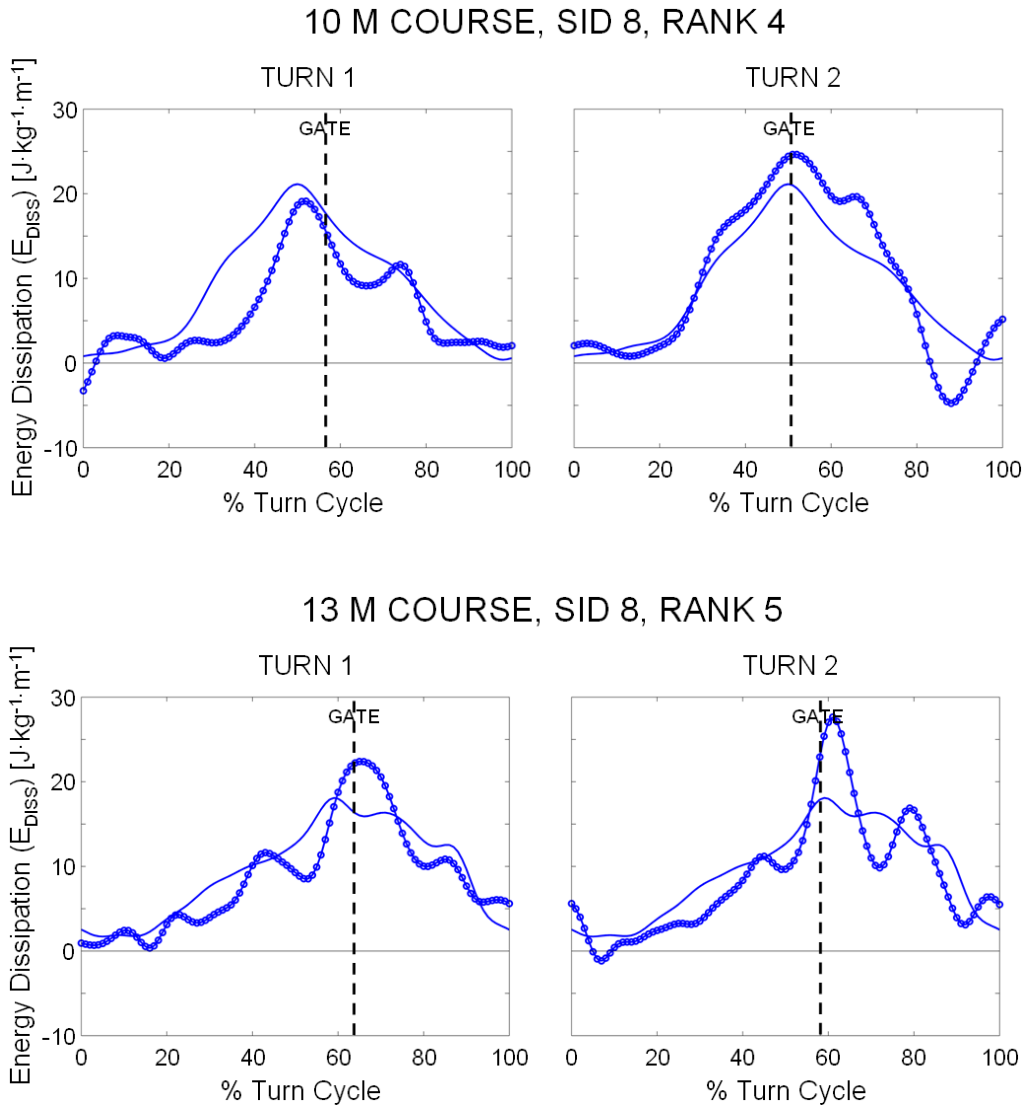


FIGURE O.4. Mechanical energy dissipation for subject 8 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

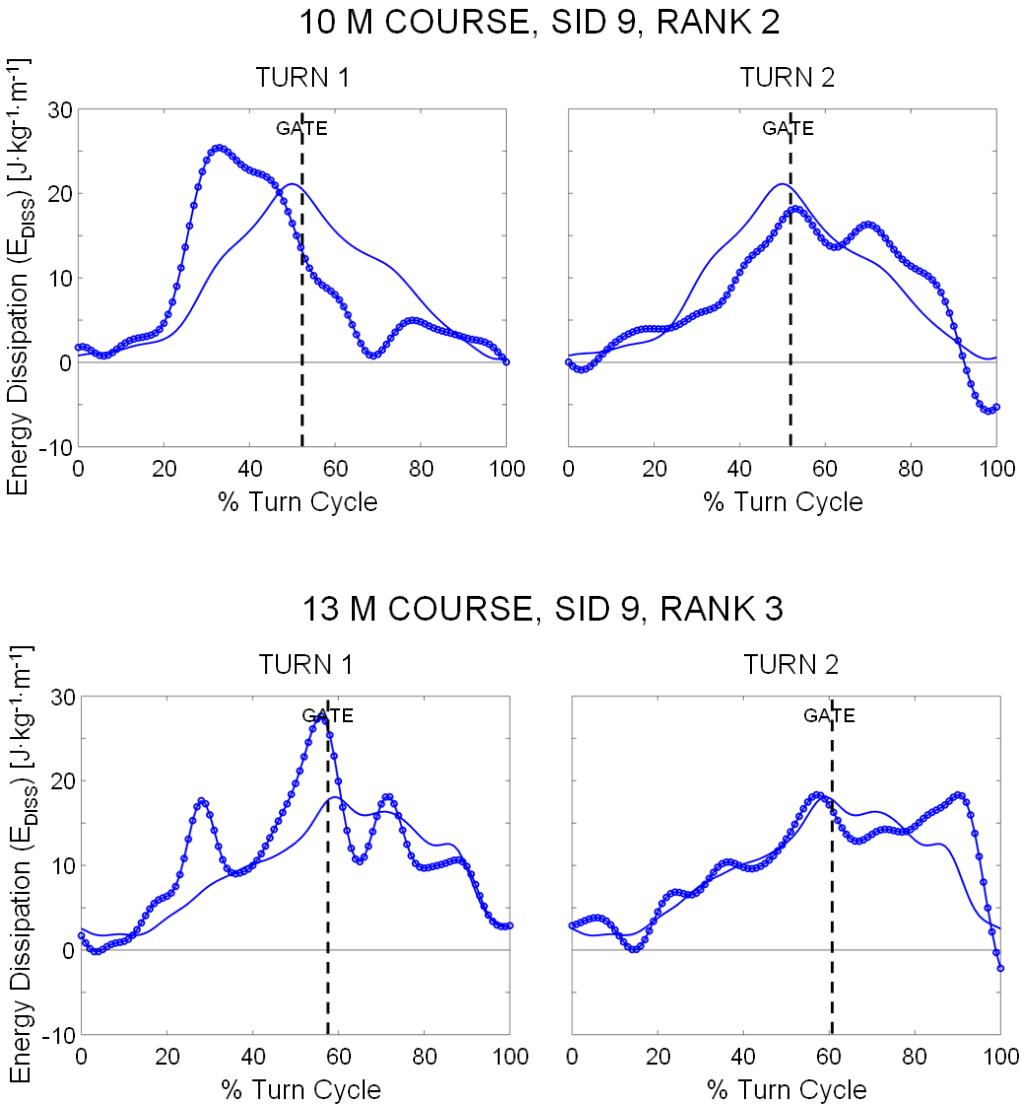


FIGURE O.5. Mechanical energy dissipation for subject 9 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

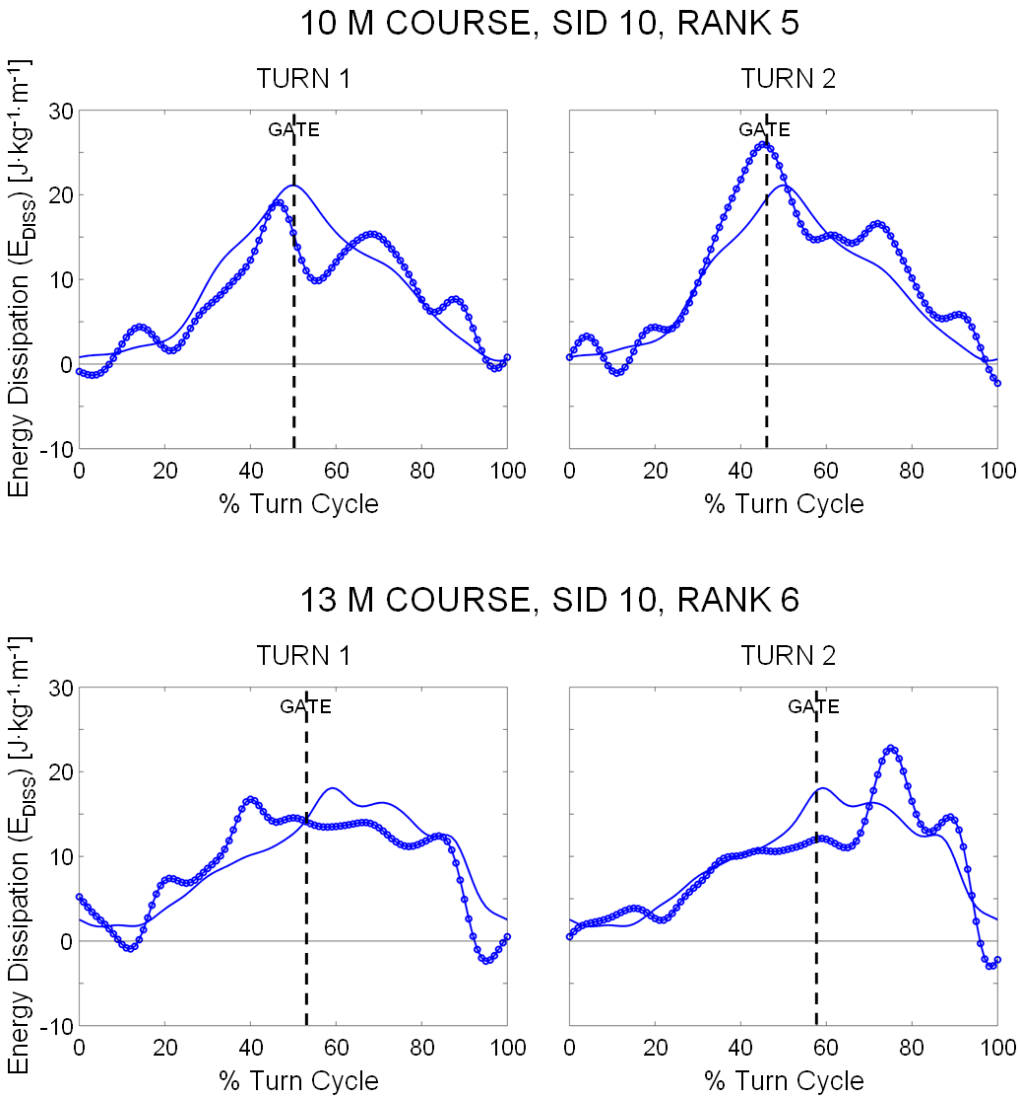


FIGURE O.6. Mechanical energy dissipation for subject 10 on both the 10 and 13 m courses. The thick line is the subject's data while the thin line is the sample ensemble average.

APPENDIX P. Scatter Plots With Performance Time

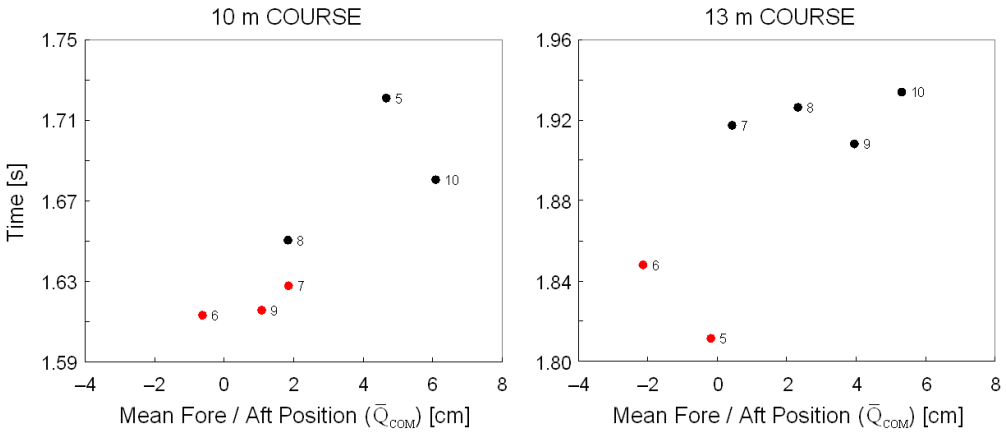


FIGURE P.1. Mean center of mass fore/aft position versus performance time. Red markers indicate the fast skiers. Marker numbers are subject identification numbers.

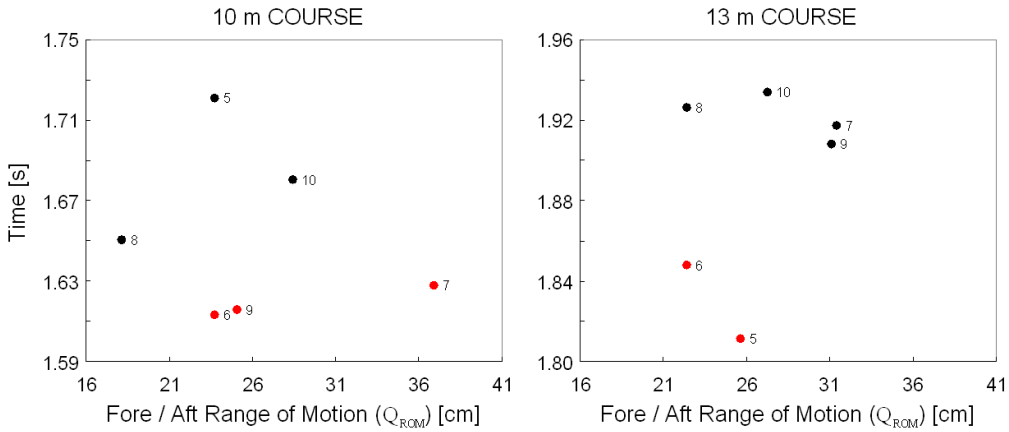


FIGURE P.2. Mean fore/aft range of motion versus performance time. Red markers indicate the fast skiers. Marker numbers are subject identification numbers.

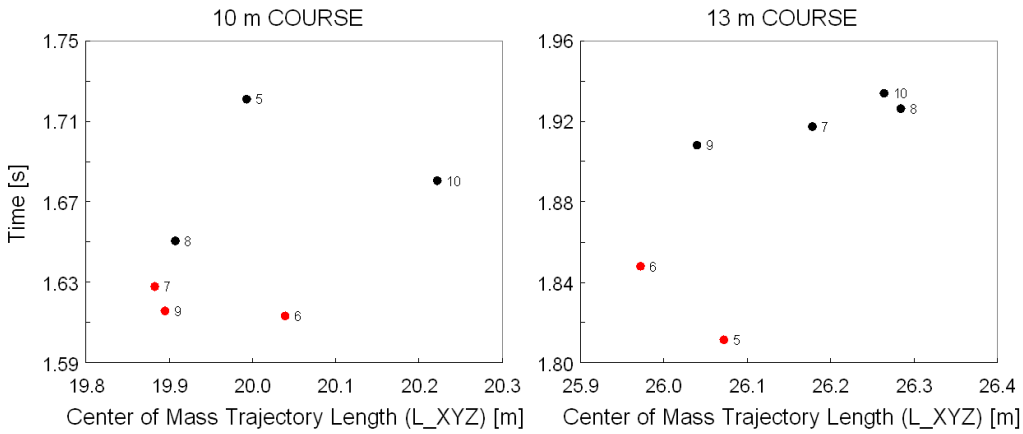


FIGURE P.3. Total center of mass trajectory length (L_{XYZ}) versus performance time. Red markers indicate the fast skiers. Marker numbers are subject identification numbers.

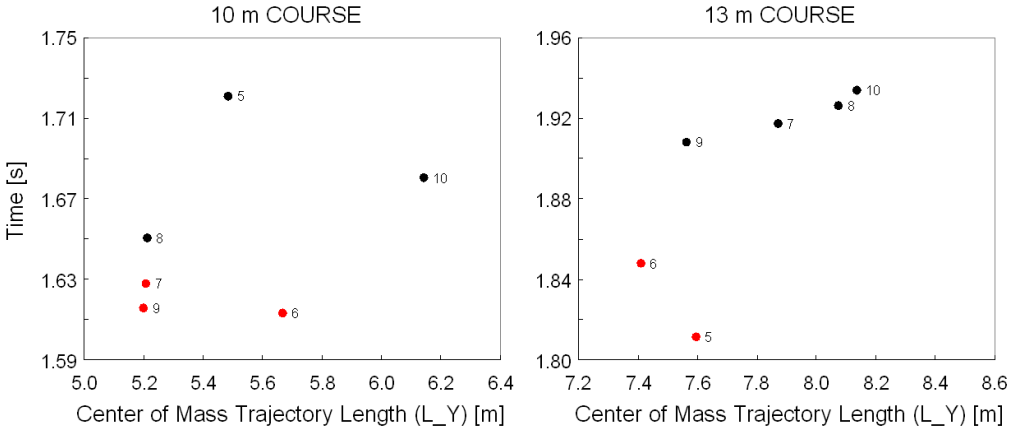


FIGURE P.4. Total center of mass trajectory length in the Y′-dimension (L_Y) versus performance time. Red markers indicate the fast skiers. Marker numbers are subject identification numbers.

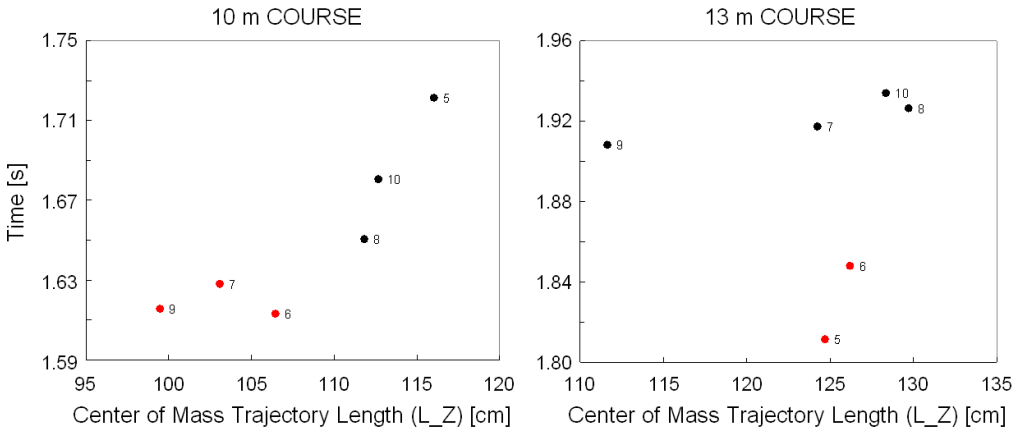


FIGURE P.5. Total center of mass trajectory length in the Z′-dimension (L_Z) versus performance time. Red markers indicate the fast skiers. Marker numbers are subject identification numbers.

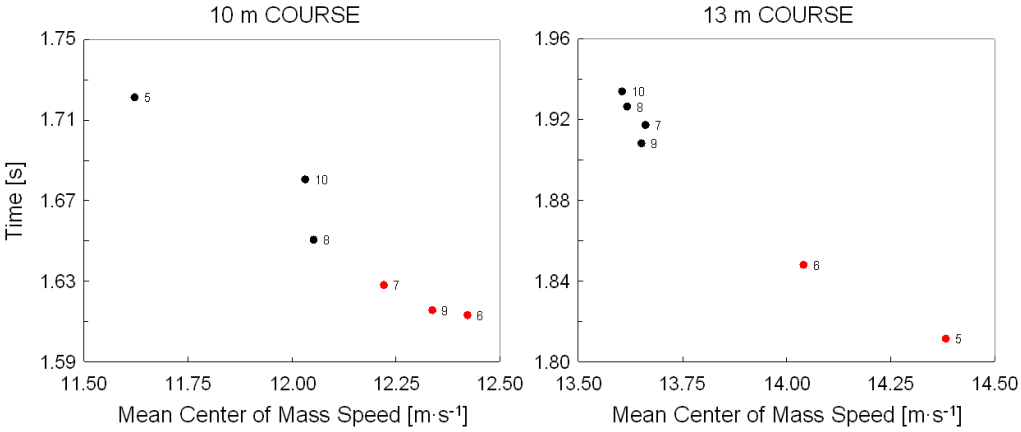


FIGURE P.6. Average center of mass speed versus performance time. Red markers indicate the fast skiers. Marker numbers are subject identification numbers.

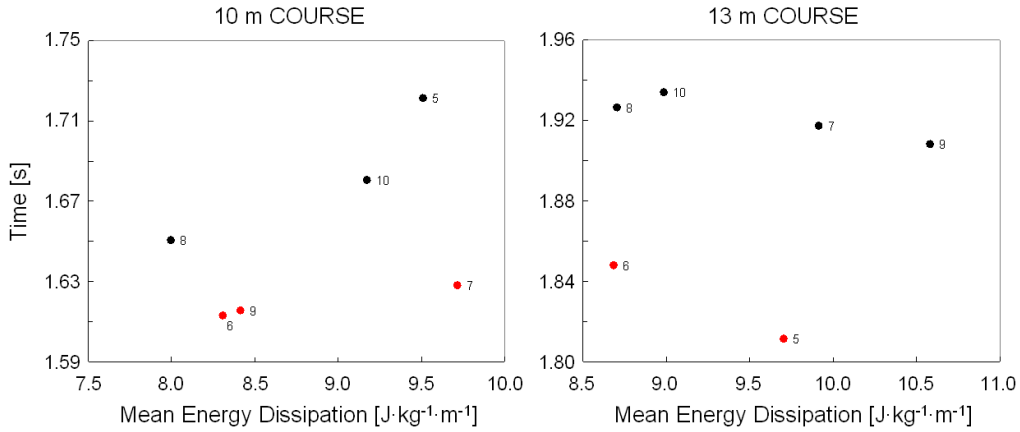


FIGURE P.7. Mean mechanical energy dissipation versus performance time. Red markers indicate the fast skiers. Marker numbers are subject identification numbers.

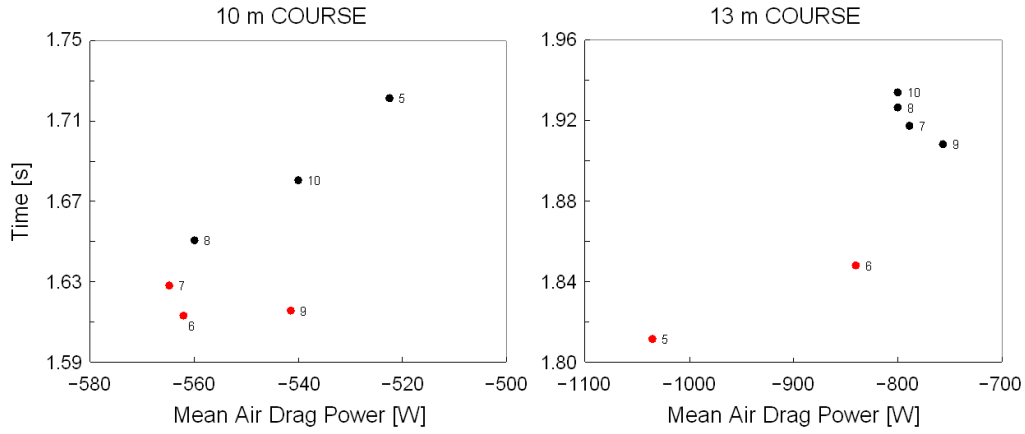


FIGURE P.8. Mean air drag power versus performance time. Red markers indicate the fast skiers. Marker numbers are subject identification numbers.

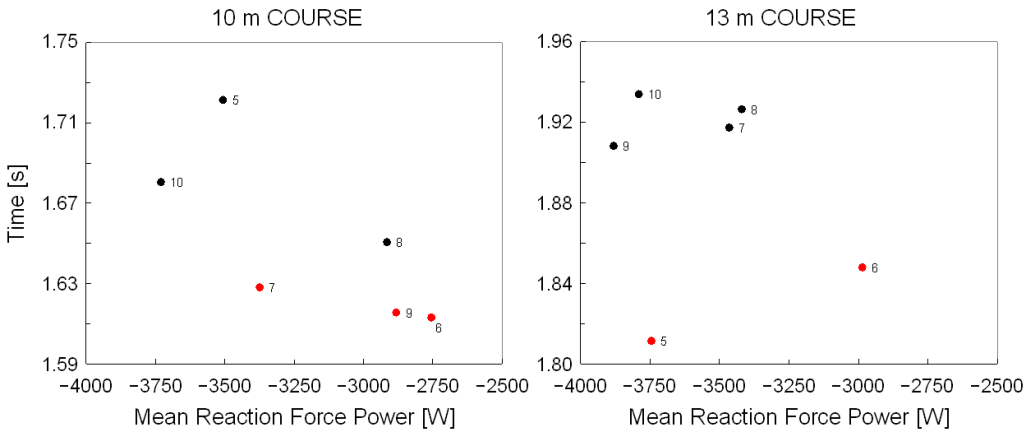


FIGURE P.9. Mean reaction force power versus performance time. Red markers indicate the fast skiers. Marker numbers are subject identification numbers.

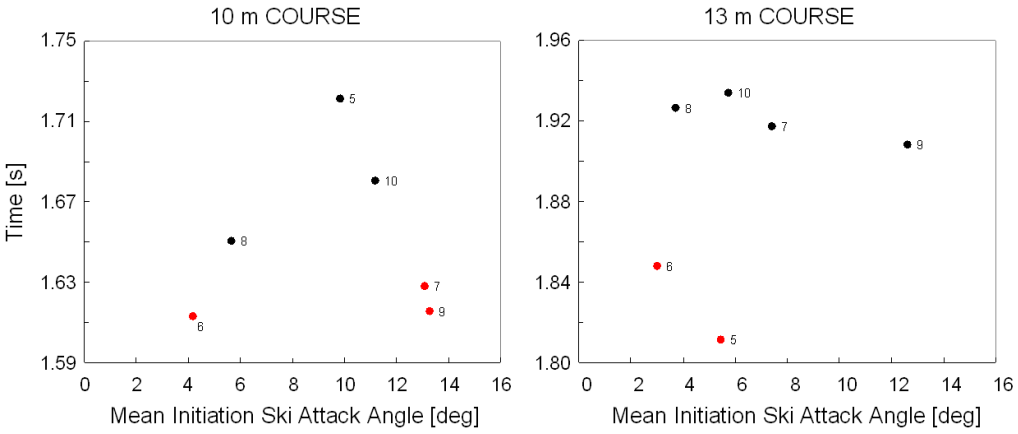


FIGURE P.10. Mean Initiation Phase outside ski attack angle versus performance time. Red markers indicate the fast skiers. Marker numbers are subject identification numbers.

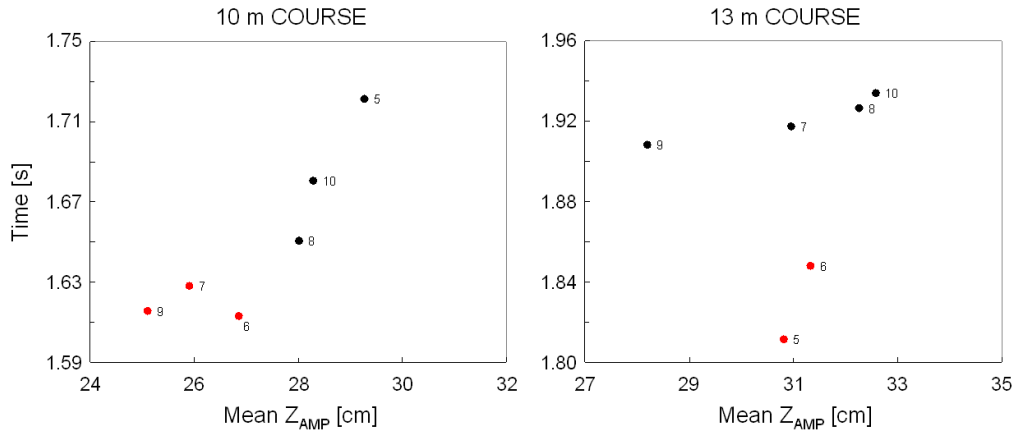


FIGURE P.11. Mean vertical motion amplitude versus performance time. Red markers indicate the fast skiers. Marker numbers are subject identification numbers.

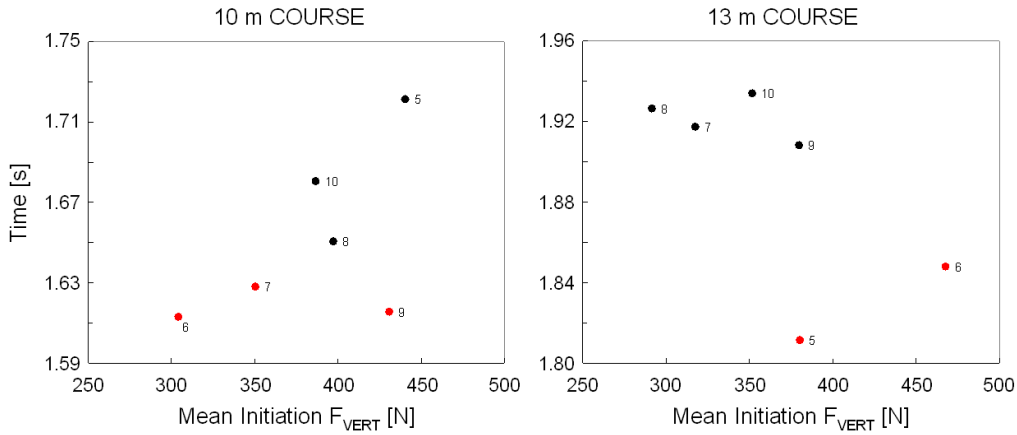


FIGURE P.12. Mean Initiation Phase snow reaction force vertical component versus performance time. Red markers indicate the fast skiers. Marker numbers are subject identification numbers.