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Study on physical fitness factors affecting race-class of Korea racing cyclists

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The purpose of this study is to compare and analyze the difference of isokinetic muscle functions, anaerobic capabilities, pedaling power and maximum strength according to race-class of Korea racing cyclists. The participants in this study were 57 racing cyclist candidates who graduated from the Korea racing school. One year after graduation, we confirmed race-class of candidates and they were divided into three groups: the first-class racer group (FC, n=14), second-class racer group (SC, n=29), third-class racer group (TC, n=14). The isokinetic muscle strength of trunk and knee flexion/extension was measured using HUMAC NORM and basic physical strength such as squat and bench press was analyzed by Ariel device. As results of this study, % Fat (percentage of body fat) in FC group was the lowest compared to other groups. Isokinetic knee flexion strength was higher in FC group than SC and TC racer groups. Peak and average pedaling power as well as maximum muscle strength were significantly higher in FC group than in other groups. Our findings suggest new evidence that pedaling power and isokinetic muscle strength might be closely associated with race-class of Korea racing cyclists.

Keywords: Maximum strength, Isokinetic muscle function, Pedaling power, Wingate test, Racing cyclist

INTRODUCTION

Cycle racing is a sprint event in which seven cyclists compete in velodrome. In the race, the cyclists ride five labs along the instructor, and then after the instructor is out, they play two laps with the maximal pedaling to decide the ranking. Race-class of Korea racing cyclists is classified by the racing score into every 6 months and their performance required to win the race are based on strong pedaling power as well as maximal muscular strength of upper and lower body (Jeukendrup et al., 2000). Also, riding strategies including domination, overtaking, breakaway and back-checking are a critical skills in determining the ranking (Willson et al., 2005).

In general, anaerobic power of athletes is measured by Wingate test (Baum and Li, 2003). Some previous studies showed close relations between anaerobic power and isokinetic knee strength (Loveless et al., 2005). According to Abt et al. (2007), the efficiency of core strength, quadriceps, and hamstring leads positive effects to padding and racing performance (da Silva et al., 2016). Not only the hamstring and quadriceps ratio of knee muscles is the factors that determine the victory (Brughelli et al., 2010; McIntyre et al., 2012) but also the improvement of muscle strength and the maximum power contributes to shorten cycling records to cyclists (Bentley et al., 2001; Koninckx et al., 2010).

In addition to isokinetic strength and maximum power, the grip strength is important fitness factors to hold steady handles and transmit upper body power to cycle (Doré et al., 2006). Sunde et al. (2010) suggested that maximal strength of upper and lower body could improve cycling economy in competitive cyclists (Craig and Norton, 2001).

There are several studies reported on correlations between fitness and racing performance of amateur cyclists so far. However, research on the variety of fitness factors that affects the race-class of Korea racing cyclists is rare. Thus, the purpose of this study is to compare and analyze the difference of performance-related isokinetic muscle functions, anaerobic capacity, pedaling power, and

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maximum strength according to race-class of Korea racing cyclists. In future study, present results will be used as data for foundation of training program to improve racing performance.

MATERIALS AND METHODS

Participants

The participants in this study were 57 candidates in Korea racing school (Table 1). One year after graduation, we confirmed race-class of candidates and then they are divided into three groups: the first-class racer group (FC, n=14), second-class racer group (SC, n=29), third-class racer group (TC, n=14). Before beginning the study, all participants had a detailed explanation of this study and submitted their written informed consent to the researchers. This research was conducted ethically according to international guidelines.

Body composition analysis

The subjects visited the laboratory by 9:00 a.m. with 8 hr of fasting. Height and body weight were measured in light clothing and without shoes using Jenix (DS-103M, Dong Sahn Jenix, Seoul, Korea). Body composition was measured by Inbody 770 (Inbody 770, Inbody, Seoul, Korea) to analyze percentage of body fat (% Fat), fat-free mass (FFM), and body mass index (BMI).

Isokinetic trunk and knee muscle strength test

Isokinetic trunk and knee flexion/extension muscle strength were measured using HUMAC NORM (Humac Norm 776, CSMi, MA, USA). The maximum isokinetic trunk strength was measured 3 times at 30°/sec. The isokinetic knee test on hamstring and quadriceps muscle strength was repeated 3 times at an angular velocity of 60°/sec. The range of the motion of trunk and knee during the tests were set from -10° to 70° and 0° to 90°, respectively. Results were shown in absolute and relative value.

Anaerobic Wingate test

Anaerobic Wingate test is a method to confirm the maximum pedaling power capability using a Monark bicycle (Ergomedic 823E, Monark Exercise AB, Vansbro, Sweden). The bearing weight of Wingate test was set as 0.075 kp. Three min after light pedalling, maximum pedaling maintained for 30 sec with the 'start' signal from when the maximum speed was reached at the set load. The peak power (PP) is the anaerobic power, the mean power is the speed-endurance, and the fatigue index (FI) is the fatigue resistance ability.

Table 1. Physical characteristics of the subjects

Variable	FC (n=14)	SC (n=29)	TC (n=14)
Age (yr)	25.5±1.5	25.5±2.1	27.1±1.9
Height (cm)	177.9±5.4	176.7±5.1	176.5±5.6
Weight (kg)	81.5±6.8	83.0±7.4	84.6±8.2

Values are presented as mean±standard deviation.
FC, first-class racer group; SC, second-class racer group; TC, third-class racer group.

Maximal muscle strength test

The basic physical strength was composed of squat, bench press, and grip strength. The grip strength (TKK 5401, Tachometer, Takei, Japan) was measured twice on left and right sides and was recorded at the highest value. The absolute value measured by Ariel (16120 Smith Press, Cybex, MA, USA) was used as a relative value for the squat and bench press. All subjects took a rest for 3 min after 5 times of preliminary exercise and then maximal muscle strength was measured.

Statistical analysis

PASW Statistics ver. 18.0 (SPSS Inc., Chicago, IL, USA) was used to confirm differences of maximum muscle strength and isokinetic knee and trunk functions between groups. Statistical analysis was performed using one-way repeated analysis of variance followed *Scheffe alpha post hoc*, and All values are expressed as mean±standard deviation. $P<0.05$ was considered significant.

RESULTS

Body composition in racer groups

We measured % Fat, FFM, and BMI to identify characteristics of racing cyclists. As shown in Table 2, % Fat ($F=3.707$, $P=0.031$) in FC group was the lowest compared to other groups. FFM ($F=0.104$) and BMI ($F=0.801$) showed no significant differences between groups.

Table 2. The different of body composition

Variable	FC[a]	SC[b]	TC[c]	*F*-value	Scheffe
% Fat (%)	16.3±4.5	18.8±3.8	20.3±3.7	3.707*	a<c
FFM (kg)	68.0±7.7	67.3±5.7	66.9±6.9	0.104	
BMI (kg/m^2)	26.1±1.3	26.7±2.0	26.9±1.9	0.801	

Values are presented as mean±standard deviation.
FC, first-class racer group; SC, second-class racer group; TC, third-class racer group; % Fat, body fat percentage; FFM, fat-free mass; BMI, body mass index.
*$P<0.05$; one-way analysis of variance.

Isokinetic trunk muscle functions among racer groups

We performed isokinetic trunk extension and flexion test at 30°/sec for identifying maximum strength and balance of core muscles. As shown in Table 3, the peak torque and flexion:extension ratio (F:E ratio) of isokinetic trunk muscle showed no significant differences between groups.

Isokinetic knee muscle functions among racer groups

We performed isokinetic knee extension and flexion test at 60°/sec for identifying maximum strength and balance of the quadriceps and hamstring muscles. As shown in Table 4, the absolute ($F=7.203$, $P=0.002$) and relative peak values ($F=3.326$, $P=0.043$) of the right flexor were highest in FC group while only relative peak values ($F=4.079$, $P=0.022$) of the left flexor showed notable difference among the groups. Also, bilateral balance ratio for knee flexor ($F=9.514$, $P=0.001$) and extensors ($F=8.844$, $P=0.001$) showed statistical difference among the groups.

Anaerobic pedaling power among racer groups

To examine difference in anaerobic pedaling power of racing cyclists, we performed Wingate test for 30 sec. As shown in Table 5, the absolute ($F=4.564$, $P=0.015$) and relative peak value ($F=23.177$, $P=0.001$) in PP as well as the absolute ($F=3.600$, $P=0.034$) and relative peak value ($F=22.618$, $P=0.001$) in average power were significantly higher in FC group compared to the SC and TC group. In the *post hoc* results, the peak values in FC group were the highest. There is not significant difference of FI between all groups.

Basic physical fitness among racer groups

Changes in maximum muscle strength of squat, bench press and hand-grip are shown in Table 6. The absolute ($F=3.721$, $P=0.031$) and relative values ($F=4.077$, $P=0.022$) in maximum squat strength as well as absolute ($F=3.715$, $P=0.031$) and relative values ($F=6.267$, $P=0.004$) in bench press were significantly

Table 3. Isokinetic trunk strength at 30°/sec

Variable	FC	SC	TC	*F*-value
Flexor (N·m)	357.8±57.2	343.4±46.4	342.4±35.5	0.521
Flexor (BW%)	292.5±55.7	283.3±32.4	289.9±43.1	0.269
Extensor (N·m)	440.9±61.9	423.9±90.8	441.2±62.7	0.342
Extensor (BW%)	359.1±54.4	349.3±68.6	371.4±52.8	0.611
F:E ratio (%)	82.4±15.1	83.1±13.2	78.7±12.0	0.507

Values are presented as mean±standard deviation.
FC, first-class racer group; SC, second-class racer group; TC, third-class racer group; N·m, Newton meter; BW, body weight; F:E ratio, flexor: extensor ratio.

Table 5. The different of Wingate test

Variable	FC[a]	SC[b]	TC[c]	*F*-value	Scheffe
PP (W)	931.49±124.3	862.5±100.2	810.9±98.1	4.564*	c<a
PP (W/kg)	11.4±0.8	10.3±0.6	9.5±0.6	23.177***	c<b<a
AP (W)	724.9±90.1	686.3±79.1	644.9±65.1	3.600*	c<a
AP (W/kg)	8.8±0.5	8.2±0.4	7.6±0.4	22.618***	c<b<a
FI (%)	46.3±9.2	50.5±5.8	50.3±7.6	1.708	

Values are presented as mean±standard deviation.
FC, first-class racer group; SC, second-class racer group; TC, third-class racer group; PP, peak power; AP, average power; FI, fatigue index.
*$P<0.05$, ***$P<0.001$; one-way analysis of variance.

Table 4. Isokinetic knee strength at 60°/sec

Variable	FC[a]	SC[b]	TC[c]	*F*-value	Scheffe
Right flexor (N·m)	189.4±17.2	169.1±16.2	168.7±20.7	7.203**	c, b<a
Right flexor (BW%)	154.2±17.4	140.5±17.8	141.4±14.4	3.326*	
Right extensor (N·m)	320.6±46.9	305.0±33.1	287.2±26.6	3.073	
Right extensor (BW%)	261.1±42.9	253.7±38.5	242.0±22.9	0.975	
Left flexor (N·m)	184.0±13.9	166.8±21.2	168.0±19.2	4.079*	b<a
Left flexor (BW%)	149.2±14.8	138.6±21.6	142.5±20.8	1.321	
Left extensor (N·m)	318.5±32.6	298.6±37.3	289.0±28.6	2.745	
Left extensor (BW%)	259.7±34.7	248.8±42.2	243.7±27.1	0.687	
Bilateral balance ratio for flexor (%)	9.1±5.4	6.0±3.1	2.7±3.2	9.514***	c<a
Bilateral balance ratio for extensor (%)	8.3±4.0	5.6±3.0	3.1±2.9	8.844***	c<a
H:Q ratio for the right (%)	58.5±10.6	55.7±5.3	59.0±8.9	1.073	
H:Q ratio for the left (%)	57.9±5.5	56.2±6.5	58.8±8.9	0.761	

Values are presented as mean±standard deviation.
FC, first-class racer group; SC, second-class racer group; TC, third-class racer group; N·m, Newton meter; H:Q ratio, Hamstring:Quadriceps ratio.
*$P<0.05$, **$P<0.01$, ***$P<0.001$; one-way analysis of variance.

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Table 6. The different of fitness level

Variable	FC[a)]	SC[b)]	TC[c)]	*F*-value	Scheffe
Squat (kg)	220.9±20.4	203.3±30.0	194.2±33.4	3.721*	c<a
Squat (kg/kg)	2.6±0.2	2.4±0.3	2.3±0.4	4.077*	c<a
Bench press (kg)	117.7±14.9	113.7±18.0	101.0±17.9	3.715*	c<a
Bench press (kg/kg)	1.4±0.1	1.3±0.2	1.2±0.2	6.267**	c<b, a
Right grip strength (kg)	68.9±12.7	60.5±5.6	56.7±9.0	7.347**	c, b<a
Left grip strength (kg)	67.7±11.8	58.2±6.4	56.3±8.7	7.361***	c, b<a

Values are presented as mean±standard deviation.
FC, first-class racer group; SC, second-class racer group; TC, third-class racer group.
$^*P<0.05$, $^{**}P<0.01$, $^{***}P<0.001$; one-way analysis of variance.

higher in FC group compared to the SC and TC group. Left ($F=7.347$, $P=0.002$) and right grip strength ($F=7.361$, $P=0.001$) showed higher value in FC group than those in other groups. In the *post hoc* results, all strength values in FC group were the highest compared to other groups.

DISCUSSION

This study analyzes isokinetic muscular strength, anaerobic power, maximum strength associated with race-class of Korean racing cyclists. In order for a race cyclist to level up to First-class, muscular strength of upper and lower body and paddling power are necessary (Jeukendrup et al., 2000). Haakonssen et al. (2016) suggested that high FFM and low % Fat of upper and lower body in cyclists are needed to maintain a maximal speed and power during the race. According to other previous studies, professional racing cyclists are formed with high FFM and low % Fat which relatively decreases the air resistance and accomplishes excellent performance (Haakonssen et al., 2016; Penteado et al., 2010). Our finding also represented higher FFM and lower % Fat in FC group compare to other groups. Therefore, cyclists in SC and TC groups require combined exercise to improve pedaling power and muscle mass in upper and lower limbs.

In present study, isokinetic trunk strength showed no significant difference among three groups, which we believe the core strength of all the cyclists is outstanding. However, only the FC groups appeared to have high knee flexor value compared to other groups. The reason for this result seemed to have come from powerful 'pulling' motion of paddling by strong hamstring muscle, suggesting enhancement of hamstring muscle strength for winning. Also, effective and balanced power of agonist and antagonist muscle in lower limbs of cyclists might intensify paddling power during racing (Rønnestad et al., 2017).

Anaerobic power is one of the most important factors at the last two laps during cycling race (Jeukendrup et al., 2000; Zagatto et al., 2009), which is correlated with sprint power of cyclists. In our findings, FC group showed higher values in PP and AP than those in SC and TC groups. These high values are resulted from successful domination, overtaking and breakaway techniques that FC cyclists play and lead to a confident race. In previous studies on relationship between muscle mass and anaerobic power, Rønnestad et al. (2010) reported that high-intensity training will increase muscle mass of quadriceps and upregulate the anaerobic power. Therefore, high-intensity interval training and sprint interval training have to apply to lower-level cyclists. Resistance and plyometric training to improve physical strength of cyclists in SC and TC groups will develop a variety of upper and lower muscles, which result in progressive race performance.

To put all the result together, enhancement of core muscle, paddling power and maximum strength muscle in SC and TC groups will allow them to promote themselves to FC group. In addition, systematic and scientific training program should be considered race to improve race performance and race techniques.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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REFERENCES

Abt JP, Smoliga JM, Brick MJ, Jolly JT, Lephart SM, Fu FH. Relationship between cycling mechanics and core stability. J Strength Cond Res 2007;21:1300-1304.

Baum BS, Li L. Lower extremity muscle activities during cycling are influenced by load and frequency. J Electromyogr Kinesiol 2003;13:181-190.

Bentley DJ, McNaughton LR, Thompson D, Vleck VE, Batterham AM. Peak power output, the lactate threshold, and time trial performance in cyclists. Med Sci Sports Exerc 2001;33:2077-2081.

Brughelli M, Cronin J, Nosaka K. Muscle architecture and optimum angle of the knee flexors and extensors: a comparison between cyclists and Australian Rules football players. J Strength Cond Res 2010;24:717-721.

Craig NP, Norton KI. Characteristics of track cycling. Sports Med 2001;31:

457-468.
da Silva JC, Tarassova O, Ekblom MM, Andersson E, Rönquist G, Arndt A. Quadriceps and hamstring muscle activity during cycling as measured with intramuscular electromyography. Eur J Appl Physiol 2016; 116:1807-1817.
Doré E, Baker JS, Jammes A, Graham M, New K, Van Praagh E. Upper body contribution during leg cycling peak power in teenage boys and girls. Res Sports Med 2006;14:245-257.
Haakonssen EC, Barras M, Burke LM, Jenkins DG, Martin DT. Body composition of female road and track endurance cyclists: normative values and typical changes. Eur J Sport Sci 2016;16:645-653.
Jeukendrup AE, Craig NP, Hawley JA. The bioenergetics of World Class Cycling. J Sci Med Sport 2000;3:414-433.
Koninckx E, Van Leemputte M, Hespel P. Effect of isokinetic cycling versus weight training on maximal power output and endurance performance in cycling. Eur J Appl Physiol 2010;109:699-708.
Loveless DJ, Weber CL, Haseler LJ, Schneider DA. Maximal leg-strength training improves cycling economy in previously untrained men. Med Sci Sports Exerc 2005;37:1231-1236.
McIntyre JP, Mawston GA, Cairns SP. Changes of whole-body power, muscle function, and jump performance with prolonged cycling to exhaustion. Int J Sports Physiol Perform 2012;7:332-339.
Penteado VSDR, Castro CHM, Pinheiro MM, Santana M, Bertolino S, de Mello MT, Szejnfeld VL. Diet, body composition, and bone mass in well-trained cyclists. J Clin Densitom 2010;13:43-50.
Rønnestad BR, Hansen EA, Raastad T. In-season strength maintenance training increases well-trained cyclists' performance. Eur J Appl Physiol 2010;110:1269-1282.
Rønnestad BR, Hansen J, Nygaard H. 10 weeks of heavy strength training improves performance-related measurements in elite cyclists. J Sports Sci 2017;35:1435-1441.
Sunde A, Støren O, Bjerkaas M, Larsen MH, Hoff J, Helgerud J. Maximal strength training improves cycling economy in competitive cyclists. J Strength Cond Res 2010;24:2157-2165.
Willson JD, Dougherty CP, Ireland ML, Davis IM. Core stability and its relationship to lower extremity function and injury. J Am Acad Orthop Surg 2005;13:316-325.
Zagatto AM, Beck WR, Gobatto CA. Validity of the running anaerobic sprint test for assessing anaerobic power and predicting short-distance performances. J Strength Cond Res 2009;23:1820-1827.

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