Original Research

TRAINING MODALITY PRACTICES OF MASTERS CYCLISTS: AN AUSTRALIAN STUDY

Campbell Macgregor [1,2] Peter Reaburn [3] and Marko T. Korhonen [4]

1. Health and Social Sciences, Faculty of Education, Health, Nursing and Social Services, Toi Ohomai Institute of Technology, New Zealand

2. Exercise and Sport Sciences, School of Health, Medical and Applied Sciences, Central Queensland University, Australia

3. Exercise and Sports Science, Bond Institute of Health and Sport, Faculty of Health, Sciences and Medicine, Bond University, Australia

4. Gerontology Research Center, Faculty of Sport and Health Sciences, University of Jyväskylä, Finland

INTRODUCTION

During the last three decades, there has been a significant increase in the number of masters athletes (over 35 y) participating in various competitive sport events (Leyk et al., 2009; Knechtle, Knechtle, Rosemann, & Senn, 2011; Lepers, Rust, Stapley, & Knechtle, 2012). The growing number of middle-aged and older competitors may be due to health and fitness, social and recreational reasons (Macgregor, Roby, & Reaburn, 2016). However, for many elite-level athletes, the major challenge is to test their own performance limits with increasing age and compete against age-matched peers (Dascomb & Raeburn, 2007).

Masters athletes are faced with the challenges caused by age-related changes in physiological systems and health affecting trainability. Research on masters runners has indicated that endurance performance is associated with the training volume (Wroblewski, Amati, Smiley, Goodpaster, & Wright, 2011). However, it seems that even among elite-level athletes, aging leads to reduction in training volume. The few available studies on masters athletes indicate that the decline in training volume is evident for both endurance and sprint/power athletes (Easthope, Hausswirth, Vercruyssen, & Brisswalter, 2010). It could be hypothesised that in the majority of aging athletes, reduced training volume is necessary to avoid overtraining.

Unexpectedly, a study by Appleby and Dieffenbach (2016) found that most masters cyclists do not have coaches, especially since competitive cycling is often considered one of the toughest endurance events. Surprisingly, little attention has been paid to masters athletes' competitive performance and training practices. Given that there are many age-related physiological changes, the information obtained from young riders may not give viable conclusions for masters cyclists. For this reason, this study set out to determine the current modes of training adopted by masters cyclists competing at state level in Australia.

METHODS

Experimental Approach to the Problem

The project used a mixed-methods approach and thus a combination of both qualitative and quantitative data collection (Christensen, Johnson, & Turner, 2011). Phase one used the focus group technique to develop the online survey tool, which was used to examine the current training practices of masters cyclists. Phase two comprised the online survey that was designed to gather quantitative data examining the training practices of masters cyclists.

Following ethical approval from the CQUniversity Human Ethics Research Panel (approval number 12-06-135), an email invitation was sent to ten local male and female masters cyclists from the Rockhampton Cycling Club asking them to participate in a focus group session designed to develop and refine an online questionnaire. Each participant received an invitation, an opt-in option, an information sheet and an informed consent document, giving the date, time and venue of the focus group. Each potential participant who responded to the e-mail invitation was then sent an email seven days before the planned focus group as a reminder, and then again on the day of the focus group meeting. Refreshments in the form of sandwiches, coffee, tea and juice were provided to the participants.

Upon arrival at the venue, the signed informed consent forms were collected from the participants. Participants were seated around a meeting table in a meeting room at CQUniversity. A series of open and closed questions were asked to initiate and facilitate discussion between the focus group participants. The focus group was recorded following consent of the participants, who were again reminded of the opt-in nature of the research and informed that if they wished to leave the meeting at any stage there was no penalty or prejudice attached.

The research project received the written support of Cycling Queensland, which provided their permission to send the online survey link to their 2012-13 membership e-mail database. An email was sent by Cycling Queensland to all current members, inviting them to participate in the research. In the email, each participant received an invitation, an opt-in option, and a hyperlink to the online questionnaire using Survey Monkey. The estimated time to complete the online questionnaire was 20 minutes, and included questions about recovery practices and the perceived benefits and constraints of participating in cycling in Queensland.

The online questionnaire included the following questions:

- What is your age at the time of this online questionnaire?
- Gender (male or female)?
- What is your height in cm?
- What is your weight in kg?
- Over the past 12 months, as an average per week, please indicate:
  - Training per week for cycling
  - Average km per week on the bike
  - Different types of training undertaken

The training questions included distance and time spent training (both 'on the bike' and 'off the bike'). There was also a specific question on whether the masters athletes were competing for fitness or to win competitions (specific training objectives). Furthermore, specific questions were asked about training 'off the bike,' whether participants attended a fitness centre or gym and if they undertook weight or resistance training.

Participants

Members of Cycling Queensland, Australia, comprised the sample population for this study. A total of 371 individuals completed the online survey. The respondents were distributed across gender and age lines – 90.56% of the respondents were male (n=336), while females (n=35) comprised 9.43%. The mean age of participants was 46.0, with N=36 aged 18-29, 134 aged 30-44, 102 aged 45-54 and 99 in the 55+ age category. The gender distribution was approximately constant over the age categories, with the mean ages of male and females in the sample not differing significantly; $t(3) = 2.17$, $p = .54$.

Statistical Analyses

Data was analysed by the R statistical programming team using standard non-parametric bivariate statistics from the core package, and stepwise multivariate regression methods from the well-known *MASS* library. The 371 responses were collated and analysed using the R open-source statistics environment.

RESULTS

According to this study, the current training modes for masters cyclists included endurance training on the bike and off the bike (running and/or swimming); strength training on the bike (with events such as biking to the hills) and off the bike (including resistance training in the gym); speed power training on the bike (which entailed sprint work) and off the bike (which entailed plyometrics, flexibility training such as stretching or yoga, skill training, and attending fitness classes at the gym).

Gender	Weights	Gym		*Total*
		No	Yes	
Female	No	26	6	32
		81.2 %	*18.8 %*	*100.0 %*
		8.3 %	**10.5 %**	**8.6 %**
	Yes	2	1	3
		66.7 %	*33.3 %*	*100.0 %*
		0.6 %	**1.8 %**	**0.8 %**
Male	No	251	38	289
		86.9 %	*13.1 %*	*100.0 %*
		79.9 %	**66.7 %**	**77.9 %**
	Yes	35	12	47
		74.5 %	*25.5 %*	*100.0 %*
		11.1 %	**21.1 %**	**12.6 %**
Total		314	57	371
		84. %	15.4 %	100.0 %
		100.0 %	**100.0 %**	**100.0 %**

Fisher's p=0.071 · df=3 · Φ_c=0.126

Table 1. Cross tabulation of gym and weight training activity (Bold numbers add down the table; italic numbers add across the table)

Table 1 summarises the proportion of males and females who did gym and weight training. Fisher's exact test with Monte Carlo simulation showed a non-significant relationship between these three variables. However, this test might be undermined by the relatively low cell counts among females who undertook each type of training. Considering bivariate relationships for gender and the likelihood of undertaking each type of training, no relationship was observed between gym ($\Phi(1)=0.041, p=.459$) and weight training ($\Phi(1)=0.046, p=.601$). When gender is left out of the analysis, there is a significant positive association between visiting the gym and undertaking weight training ($\Phi(1)=0.116, p=.034$) (Table 2).

Gym	Weights	Age				*Total*
		<30	30-44	45-54	55+	
No	No	27	105	70	75	277
		9.7 %	*37.9 %*	*25.3 %*	*27.1 %*	*100.0 %*
		75 %	**78.4 %**	**68.6 %**	**75.8 %**	**74.7 %**
	Yes	2	13	14	8	37
		5.4 %	*35.1 %*	*37.8 %*	*21.6 %*	*100.0 %*
		5.6 %	**9.7 %**	**13.7 %**	**8.1 %**	**10 %**
Yes	No	5	11	16	12	44
		11.4 %	*25 %*	*36.4 %*	*27.3 %*	*100.0 %*
		13.9 %	**8.2 %**	**15.7 %**	**12.1 %**	**11.8 %**
	Yes	2	5	2	4	13
		15.4 %	*38.5 %*	*15.4 %*	*30.8 %*	*100.0 %*
		5.6 %	**3.7 %**	**2 %**	**4 %**	**3.4 %**
Total		36	134	102	99	371
		9.7 %	*36.1 %*	*27.5 %*	*26.7 %*	*100.0 %*
		100.0 %	**100.0 %**	**100.0 %**	**100.0 %**	**100.0 %**

Fisher's p=0.546 · df=9 · Φ_c=0.081

Table 2. Cross tabulation of gym and weight training activity by age category (Bold numbers add down the table; italic numbers add across the table)

Weight and gym activity by age category are shown in Table 2. Log-linear analysis did not reveal any significant relationship between age category and the likelihood of undertaking weight training ($\chi^2(3)=0.756, p=.860$) or gym training ($\chi^2(3)=2.126, p=.547$). Table 3 summarises the relationship between gym training and specific training objectives. Those participants who undertook gym training were more likely to nominate weights (strength) training as a specific training objective $\chi^2(1)=4.291, p=.038$. However, no such relationship was found for fitness $\chi^2(1)=0.682, p=.409$.

Gym	*Weights* No	Yes	*Total*	*Fitness* No	Yes	*Total*
No	182	132	314	260	54	314
	58 %	*42 %*	*100.0 %*	*82.8 %*	*17.2 %*	*100.0 %*
	88.3 %	**80 %**	**84.7 %**	**85.5 %**	**80.6 %**	**84.7 %**
Yes	24	33	57	44	13	57
	42.1 %	*57.9 %*	*100.0 %*	*77.2 %*	*22.8 %*	*100.0 %*
	11.7 %	**20 %**	**15.4 %**	**14.5 %**	**19.4 %**	**15.4 %**
Total	206	165	371	304	67	371
	55.5 %	*44.5 %*	*100.0 %*	*81.9 %*	*18.1 %*	*100.0 %*
	100.0 %	**100.0 %**	**100.0 %**	**100.0 %**	**100.0 %**	**100.0 %**

X^2=4.291 · df=1 · Φ=0.115 · p=0.038 *X^2=0.682 · df=1 · Φ=0.053 · p=0.409*

Table 3. Relationship between gym training and specific training objectives: weights and fitness (Bold numbers add down the table; italic numbers add across the table)

The relationship between gym training and specific training objectives is summarised in Table 3. Those participants who undertook gym training were more likely to nominate resistance (strength) training as a specific training objective χ^2 (1)=4.291,p=.038. However, no such relationship was found for fitness χ^2 (1)=0.682,p=.409. Table 4 shows the corresponding relationships between (off-bike) strength training and resistance and fitness objectives. Off-bike strength training was strongly related to fitness objectives χ^2 (1)=45.008,p<.001, but was unrelated to weights χ^2 (1)=0.996,p=.318.

Strength (Off-bike)	*Weights* No	Yes	*Total*	*Fitness* No	Yes	*Total*
No	182	24	206	194	12	206
	88.3 %	*11.7 %*	*100.0 %*	*94.2 %*	*5.8 %*	*100.0 %*
	56.7 %	**48 %**	**55.6 %**	**63.8 %**	**17.9 %**	**55.5 %**
Yes	139	26	165	110	55	165
	84.2 %	*15.8 %*	*100.0 %*	*66.7 %*	*33.3 %*	*100.0 %*
	43.3 %	**52 %**	**44.5 %**	**36.2 %**	**82.1 %**	**44.4 %**
Total	321	50	371	304	67	371
	86.5 %	*13.5 %*	*100.0 %*	*81.9 %*	*18.1 %*	*100.0 %*
	100.0 %	**100.0 %**	**100.0 %**	**100.0 %**	**100.0 %**	**100.0 %**

X^2=0.996 · df=1 · Φ=0.060 · p=0.318 *X^2=45.008 · df=1 · Φ=0.355 · p=0.000*

Table 4. Relationship between strength training (off-bike) and specific training objectives: weights and fitness (Bold numbers add down the table; italic numbers add across the table)

Table 4 shows the relationships between (off-bike) strength training and weight and fitness objectives. Off-bike strength training was strongly correlated to fitness objectives χ^2 (1)=45.008,p<.001, but was unrelated to weights χ^2 (1)=0.996,p=.318.

Strength Training (Off-bike)	*Speed/Power Training (Off-bike)*		*Total*	*Endurance Training (Off-bike)*		*Total*
	No	Yes		No	Yes	
No	206	0	206	156	50	206
	100 %	*0 %*	*100.0 %*	*75.7 %*	*24.3 %*	*100.0 %*
	61.7 %	**0 %**	**55.5 %**	**59.1 %**	**46.7 %**	**55.5 %**
Yes	128	37	165	108	57	165
	77.6 %	*22.4 %*	*100.0 %*	*65.5 %*	*34.5 %*	*100.0 %*
	38.3 %	**100 %**	**44.5 %**	**40.9 %**	**53.3 %**	**44.5 %**
Total	334	37	371	264	107	371
	90 %	*10 %*	*100.0 %*	*71.2 %*	*28.8 %*	*100.0 %*
	100.0 %	**100.0 %**	**100.0 %**	**100.0 %**	**100.0 %**	**100.0 %**
X^2=48.844 · df=1 · Φ=0.372 · p=0.000				*X^2=4.224 · df=1 · Φ=0.113 · p=0.040*		

Table 5. Relationship between undertaking off-bike strength training and other forms of off-bike training (Bold numbers add down the table; italic numbers add across the table)

For off-bike training objectives, there was a marked correlation between strength and speed/power objectives, as shown in Table 5. Every respondent indicating speed/power training was also undertaking strength training, leading to a strong association between these objectives, χ^2 (1)=48.844,p<.001. There was a less marked, but significant, association between strength training and endurance training, χ^2 (1)=4.224,p=.040. However, there was no association between endurance training and speed/power training χ^2 (1)=1.176,p=.279.

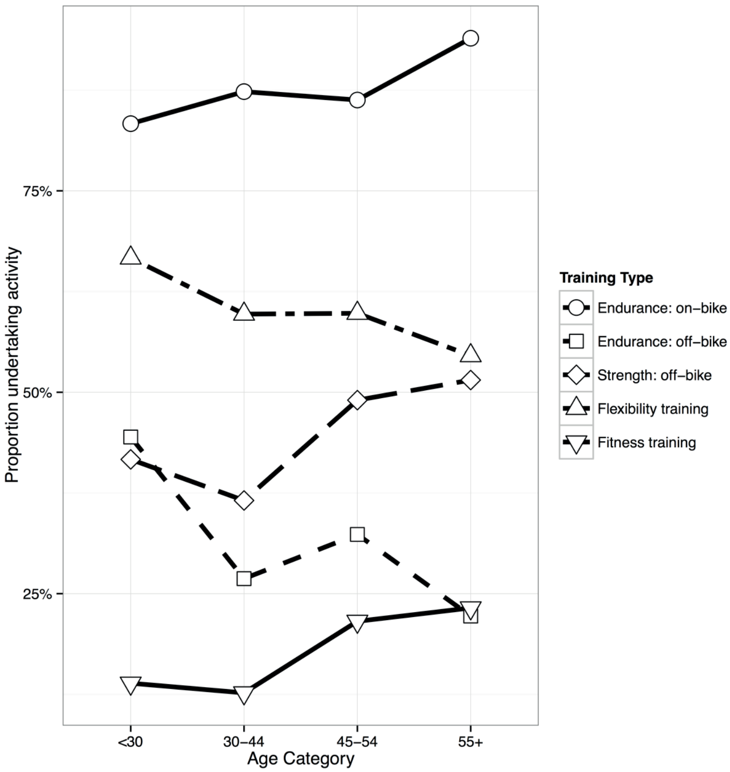

Figure 1. Graphical representation of age effects on training type.

In order to better understand the overall differences in training style between older and younger participants, a linear regression model predicting age of respondent was considered, using all training measures as candidate predictors. Stepwise model selection was performed, using the Akaike Information Criterion (AIC), which balances explanatory power with model parsimony, to select predictors. Figure 1 summarises the final (minimum AIC) regression model. The final model indicates that older participants were more likely to undertake on-bike endurance training, and less likely to undertake off-bike endurance training. Older participants were also less likely to undertake some form of flexibility training.

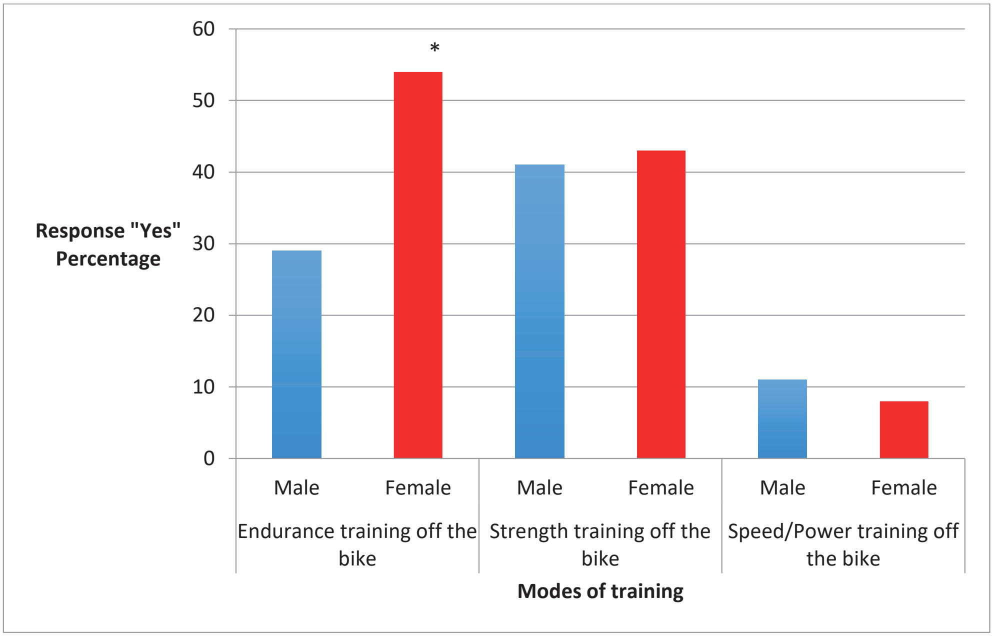

Figure 2. Training type conducted on the bike (percentages) for male and female masters cyclists. * denotes significant difference ($p < 0.05$) between male and female cyclists.

Figure 2 shows the proportion of respondents who undertook various modes of training; error bars indicate 95% confidence intervals of the proportion. The figure illustrates that there were large and significant differences in the proportion of respondents undertaking each form of training, with the exception of on-bike endurance and strength training. No gender differences were observed in terms of undertaking on- versus off-bike training for the three different training objectives. However, the small proportion of females (N=35) meant that the likelihood of detecting valid gender differences was extremely low. No age differences were observed in terms of preferring on- or off-bike training for increasing strength or speed/power. However, those participants who undertook off-bike endurance training were younger (M = 43.6) than those who did not (M = 47.5), $t(222.0) = 2.89$, $p = .004$. Although falling just short of the .05 criterion for a two-tailed test, those participants who indicated the use of on-bike endurance were older (M = 46.8), compared to those who did not (M = 43.0), $t(52.8) = 1.82$, $p = .073$.

DISCUSSION

In terms of gender difference, the study showed that females (55.6%) preferred to undertake endurance training off-the-bike 2(1, N = 208) = 7.37, p =0.01. compared to males (29.3%), suggesting that females had greater variety in their modes of training. However, the results showed no significant difference in any training variables between age groups. Our study also showed that masters cyclists undertook minimal training off the bicycle. Kraemer et al. (2001) state that resistance training is believed to increase muscle strength, muscle endurance and sprint performance, which are considered important in improving maximal, endurance and explosive muscle force – the determining factors of the level of performance achieved in sport. Lepers et al. (2012), found that endurance appears to be maintained until 35–40 years of age, followed by modest decreases until 50, then declining into older age. This is mainly the result of the physiological factors that contribute to age-related declines, which can be regulated by changing the intensity and volume of older endurance athletes' training regimes (Reaburn & Dascombe, 2008).

Our study also shows that masters cyclists use a blend of vigorous training methods, techniques and workouts. With the majority indicating that they engaged in several modes of training, most cyclists believe that varied training plays an important part in cycling performance. However, with a limited number of masters cyclists engaging in strength and speed power training off the bike, it is apparent that most of the training practices taken up by masters cyclists in Australia are based on cycling activities.

This study indicates that the performance levels of masters cyclists are likely to be extended beyond the ordinary competing age. This is mainly boosted by sports-specific training. Sillanpää, Häkkinen, Holviala and Häkkinen (2012) observed that regular physical training is an effective tool in preventing age-related losses in muscle mass, decline in physical and functional performance and several age-related diseases. Modes of training chosen by masters cyclists were able to achieve these goals since they entail gradual and progressive increase in aerobic training; extensive use of resistance and circuit training to develop muscular strength; plyometric training and bounding to develop explosive muscle power; and stretching and the use of active recovery processes.

Another finding of our study is that the modes of training adopted by masters cyclists may differ according to gender. For example, females used endurance training off the bike, while males only used this sparingly. Endurance training off the bike involved events such as running and swimming. According to Etter et al. (2013), an increase in female participation and an improvement in performance has been observed in studies investigating the participation and performance trends of female endurance runners during the last three decades. Another aspect linked to the increase in participation by female triathletes is motivation to win prize money, having fun and staying in good health (Etter et al., 2013).

Apart from being an indicator of gender differences in some modes of training for masters cyclists, this result is also an indicator that women might have greater fatigue resistance than men and that their performances might be equal or better than their male counterparts. This also confirms that there is no increased decline with aging in the longer endurance events for female performers compared to males (Baker & Ta, 2010). In addition, Esteve-Lanao, Foster, Seiler and Lucia (2007) observed that endurance runners spent the majority (71%) of their training time working at low intensities. However, they trained for longer.

The current study also discovered that masters cyclists only undertake limited strength training and speed power training off the bike. This appears to be a gap in the training habits of older cyclists. According to Lepers et al. (Lepers et al., 2012), in terms of the overall time taken, endurance and ultra-endurance performance is maintained until 35–40 years of age, followed by modest decreases until 50, with a progressive decline in performance thereafter, with the greatest declines occurring after 70. This is mainly the result of physiological factors, both central (maximum heart rate; maximum stroke volume; blood volume) and peripheral (muscle mass; muscle fibre composition, size and capillarisation; muscle enzyme activity), which contribute to age-related declines in endurance performance in older athletes. However, these physiological factors can be regulated by changing the intensity and volume of training regimes for older endurance athletes (Reaburn & Dascombe, 2008; Wang, 2008).

Maintaining and enhancing physical and physiological fitness in old age has been identified as an important step towards living better lives (Sillanpää et al., 2012). Quality of life is an aspect of health experienced from the subject's point of view, and could also be expressed as "subjective health" or "functional status and well-being" (Sillanpää et al., 2012). Masters cyclists adopt different modes of training for different reasons including improvement in sports performance, better health and even just for fun (Reaburn & Dascombe, 2008). Improvement in an athlete's quality of life has been shown to result from different modes of training.

Endurance training has also been observed to improve certain dimensions of HRQoL in middle-aged people (Sillanpää et al., 2012). As a result, masters athletes have the opportunity to face the effects of ageing with minimal interference by co-morbidity and sedentarism (Michaelis et al., 2008). However, the lack of organised training modes may encourage masters cyclists to engage in ineffective training practices which could limit these positive effects and, in the worse cases, cause over-training syndrome and affect the individual's health.

While opening the door to further research on masters cyclists, this study has identified the different training modes adopted by masters cyclists in Queensland, Australia. There are indicators that, since masters cyclists often train with little guidance from coaches (Appleby & Dieffenbach, 2016), they may be engaging in unorganised and even detrimental training. Hence the need to focus on developing organised training for masters cyclists, both on and off the bike, with a view to finding ways to optimise masters cyclists' training.

CONCLUSION

The study found that female riders prefer to undertake endurance training off the bike, as compared to males. Our findings also show that the majority of both genders do not undertake strength or power speed training off the bike, and that there is no difference for age. As resistance training has been shown to increase muscle mass and muscular strength, and is also associated with improved endurance performance, masters cyclists may benefit from undertaking increased training off the bike. In light of our findings, it is recommended that coaches and athletes need to scrutinise the different types and modes of training undertaken by masters cyclists in order to improve performance.

CORRESPONDING AUTHOR:

Dr Campbell MacGregor, Tui Ohomai; Email: campbell.macgregor@toiohomai.ac.nz; Tel: 0800864646

REFERENCES

Appleby, K. M., & Dieffenbach, K. (2016). "Older and faster": Exploring elite masters cyclists' involvement in competitive sport. *The Sport Psychologist*, *30*(1), 13–23.

Baker, A.B., & Ta, Y. Q. (2010). Aging performance for masters records in athletics, swimming, rowing, cycling, triathlon, and weightlifting. *Experiential Aging Research*, *36*, 453–477. doi: 10.1080/0361073X.2010.507433

Christensen, L. B., Johnson, R. B., & Turner, L. (2011). *Research methods, design, and analysis.* Boston: Pearson/Allyn and Bacon.

Esteve-Lanao, J., Foster, C., Seiler, S., & Lucia, A. (2007). Impact of training intensity distribution on performance in endurance athletes. *Journal of Strength & Conditioning Research*, *21*, 943–949.

Easthope, C. S., Hausswirth, C., Vercruyssen, F., & Brisswalter, J. (2010). Effects of a trail running competition on muscular performance and efficiency in well-trained young and master athletes. *European Journal of Applied Physiology*, *110*(6), 1107–1116. doi:10.1007/s00421-010-1597-1

Etter, F., Knechtle, B., Bukowski, A., Rüst, C., Rosemann, T., & Lepers, R. (2013). Age and gender interactions in short distance triathlon performance. *Journal of Sports Sciences*, *31*, 996–1006.

Francesca, P. M., De Ioannon, G., Comotto, S., Spedicato, A., Vernillo, G., & La Torre, A. (2013). Concurrent strength and endurance training effects on running economy in master endurance runners. *Journal of Strength & Conditioning Research*, *27*, 2295–2303.

Hajkowicz, S., Cook, H., Wilhelmseder, L., & Boughen N. (2013). *The future of Australian sport: Megatrends shaping the sports sector over coming decades*. A Consultancy Report for the Australian Sports Commission. CSIRO, Australia. Retrived from http://golfnetworkadmin.gamznhosting.com/site/_content/document/00017554-source.pdf

Knechtle, B., Knechtle, P., Rosemann, T., & Senn, O. (2011). Personal best time and training volume, not anthropometry, is related to race performance in the 'Swiss Bike Masters' mountain bike ultramarathon. *Journal of Strength and Conditioning research / National Strength & Conditioning Association*, *25*, 1312–1317. doi: 10.1519/JSC.0b013e3181d85ac4

Kraemer, W.J., Mazzetti, S.A., Nindl, B.C., Gotshalk, L.A., Volek, J. S., & Bush, J.A. (2001). Effect of resistance training on women's strength/power and occupational performances. *Med Sci Sports Exerc*, *33*, 1011–1025.

Lepers, R., Rust, C. A., Stapley, P. J., & Knechtle, B. (2013). Relative improvements in endurance performance with age: Evidence from 25 years of Hawaii ironman racing. *Age, 35*(3). doi: 10.1007/s11357-012-9392-z

Leyk, D., Erley, O., Ridder D., Leurs, M., Rüther, T., & Wunderlich, M. (2009). Age-related changes in endurance performances. *Int J SportsMed*, doi: 10.1055/s-2006-924658.

Michaelis, I., Kwiet, A., Gast, U., Boshof, A., Antvorskov, T., Jung, T., Rittweger, J., & Felsenberg, D. (2008). Decline of specific peak jumping power with age in master runners. *Journal of Musculoskeletal Neuronal Interaction*, *8*, 64–70.

Ransdell, L. B., Vener, J., & Huberty, J. (2009). Masters athletes: An analysis of running, swimming and cycling performance by age and gender. *J Exerc Sci Fit*, *7*, S61–S73.

Reaburn, P., & Dascombe, B. (2008). Endurance performance in masters athletes. *Euro Rev Aging & Phy Act, 5*, 31–42.

Sillanpää, E., Häkkinen, K., Holviala, J., & Häkkinen, A. (2012). Combined strength and endurance training improves health-related quality of life in healthy middle-aged and older adults. *International Journal of Sports Medicine*, *33*, 981–986.

Suominen, H. (2011). Ageing and maximal physical performance. *European Reviews of Aging & Physical Activity*, *8*, 37–42.

Tanaka, H., & Seals, D. R. (2003). Dynamic exercise performance in masters athletes: Insight into the effects of primary human aging on physiological functional capacity. *Journal of Applied Physiology*, *95*, 2152–2162. doi: 10.1152/japplphysiol.00320.2003

Tanaka, H., & Seals, D. R. (2008). Endurance exercise performance in masters athletes: Age-associated changes and underlying physiological mechanisms. *J Physiol*, *586*, 55–63.

Wang, L-I. (2008). The kinetics and stiffness characteristics of the lower extremity in older adults during vertical jumping. *Journal of Sports Science & Medicine*, *7*(3), 379–386.

Wroblewski, A. P., Amati, F., Smiley, M., Goodpaster, B., & Wright, V. (2011). Chronic exercise preserves lean muscle mass in masters athletes. *The physician and Sportsmedicine*, *39*(3), 172–8.