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Review article

Swimming and cycling do not cause positive effects on bone mineral density: a systematic review

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ABSTRACT

Osteoporosis is considered a common metabolic bone disease and its prevalence is increasing worldwide. In this context, physical activity has been used as a non-pharmacological tool for prevention and auxiliary treatment of this disease. The aim of this systematic review was to evaluate the effects of cycling and swimming practice on bone mineral density (BMD). This research was conducted in accordance with the recommendations outlined by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses. The studies were consulted in the period from 2004 to 2014, through major electronic databases: PubMed®, SciELO® and LILACS®. Ten studies evaluated the effects of cycling on BMD, and the results showed that nine studies have linked the practice of professional cycling with low levels of BMD. Another 18 studies have reported that swimming has no positive effects on bone mass. We conclude that cycling and swimming do not cause positive effects on BMD; thus, these are not the most suitable exercises for prevention and treatment of osteoporosis.

Natação e ciclismo não causam efeitos positivos na densidade mineral óssea: uma revisão sistemática

Palavras-chave:
Osteoporose
Osteopenia
Densidade óssea
Exercício físico
Atividade física

RESUMO

A osteoporose é considerada uma doença osteometabólica comum e sua prevalência está aumentando mundialmente. Nesse contexto, a atividade física tem sido usada como ferramenta não farmacológica para prevenir e auxiliar no tratamento dessa doença. O objetivo desta revisão sistemática foi avaliar os efeitos da prática do ciclismo e da natação na densidade mineral óssea (DMO). Esta pesquisa foi feita de acordo com as recomendações do Preferred Reporting Items for Systematic Reviews and Meta-Analyses. Os estudos foram consultados entre 2004 e 2014, por meio de importantes bases de dados eletrônicas: PubMed®, SciELO® e Lilacs®. Dez pesquisas avaliaram os efeitos do ciclismo sobre a DMO, os

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resultados demonstraram que nove estudos associaram a prática do ciclismo profissional com baixos níveis de DMO. Outros 18 estudos relataram que a natação não tem efeitos positivos sobre a massa óssea. Conclui-se que o ciclismo e a natação não causam efeitos positivos na DMO. Assim, não são os exercícios mais indicados para a prevenção e o tratamento da osteoporose.

Introduction

Osteoporosis is a disease characterized by a decrease in bone mineral density (BMD) and by a microarchitectural deterioration of bone tissue, leading to enhanced bone fragility and increased risk of fractures.[1] At present, osteoporosis is considered the most common metabolic bone disease, affecting mainly older people, and with a higher incidence in women, especially after menopause.[2]

According to the International Osteoporosis Foundation,[3] about 200 million women worldwide are affected by osteoporosis. In the European Community, from those 25 million people affected by this disease, about 80% are female.[4] In Brazil, a study with a representative sample found a prevalence of fractures in 15.1% and 12.8% in women and men over 40 years, respectively.[5]

The main risk factors for developing osteoporosis include: genetic predisposition,[6] advanced age in association with morphological changes[2] (*e.g.*, a decrease in bone and muscle mass), a sedentary lifestyle especially in childhood and adolescence (taking into account that these are important stages to obtain a peak bone mass),[7] and nutritional deficits.[8] In this regard, it is noted that a large portion of risks factors are modifiable (behavioral). Thus, healthy habits and adequate levels of physical activity contribute to the prevention of this disease.

Among the non-pharmacological approaches for prevention and treatment of osteoporosis, physical activity has been recommended. However, the benefits promoted by physical activity on BMD are due in part to the intensity and type of exercise,[9] as well as to the control of the biological principles of training.[7]

Previous studies have shown that different types of physical activity[10] (swimming, cycling) as well as its intensity[9] (endurance and sprint) can even affect negatively BMD. Thus, the aim of this study was to evaluate the effects of cycling and swimming practice on bone mineral density, due to the high number of practitioners[11] of these modalities, their popularity and also considering their indication by health professionals.

Methods

This systematic review was conducted in accordance with the recommendations and criteria set by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).[12]

The studies were accessed from 2004 to 2014, through a survey in electronic databases: PubMed® (http://www.ncbi.nlm.nih.gov/pubmed), SciELO® (http://www.scielo .org) and LILACS® (http://www.bireme.br).

Electronic search in databases

The following terms were adopted in a combined and/or individual way to search for articles: osteoporosis, bone density, bone mineral density, cycling and swimming. In SciELO® and LILACS® databases the terms mentioned above were entered in Portuguese.

Study selection and data extraction

The evaluation of the studies was performed by two reviewers, and when necessary, a third reviewer resolved disagreements.

Inclusion criteria:

1) Types of study: descriptive, cross-sectional, longitudinal, randomized controlled and non-randomized controlled trials evaluating the effects of cycling and swimming on BMD.
2) Types of participants: adolescents, adults and older subjects. There was no restriction as to gender.
3) Types of results evaluated: whole body BMD with subregions (upper limbs or arms and lower limbs or legs), lumbar spine, and hip with sub-regions (femoral neck, trochanter, intertrochanteric region, and Ward' s triangle).

Exclusion criteria:

1) Studies in other languages than English, Portuguese or Spanish.
2) Studies with animal models.

Results

Initially 281 relevant articles were identified. After the title and abstract review, and with eventual duplicates already discarded, the total was reduced to 49 potentially relevant documents. Of these articles, 29 met the selection criteria and were included in this study (Fig. 1).

Ten studies[10,13–21] evaluating the effects of cycling on BMD (Table 1) were found. The results showed that nine studies have associated the practice of professional cycling with low levels of BMD. Furthermore, most of the studies compared BMD of cyclists and control groups, suggesting that this sport can be considered a risk factor for early development of osteopenia/osteoporosis.

Nineteen studies[9,22–39] evaluated the effects of swimming on BMD (Table 2). The results showed that swimming has no positive effects on bone mass. Some cross-sectional studies compared BMD between professional swimmers and control

Table 1 – Studies evaluating the effects of cycling on BMD.

Author	Sample	Training time	Age	Study design	Results
Abe et al.[13] (2014)	14 cycling (masters) 13 moderately active youngsters (M)	17 years of training	20–71	Cross-sectional	BMD in lower part of femoral neck of cyclists *versus* control. ND in BMD of lumbar spine.
Sherk et al.[19] (2014)	14 cycling (F)	>1 year of competition history	26–41	Longitudinal (1 year)	BMD of the hip decreases 1–2% after a year of training and competition.
Gómez-Bruton et al.[20] (2013)	20 cycling 19 control (M)	10 h/wk	16.4 16.7	Cross-sectional	Lower BMD of young cyclists in some places.
Guillaume et al.[14] (2012)	29 cycling (M)	25,000–30,000 km/year	26–5	Descriptive	ND between groups on calcium and vitamin D intake
Nichols et al.[15] (2011)	19 cycling 18 control (M)	11.1 h/wk 4.5 h/wk	50–57	Longitudinal (7 years)	Cycling has not demonstrated positive effects on BMD. High rate of osteopenia/osteoporosis in cyclists (84.2% and 89.5% after seven years)
Olmedillas et al.[16] (2011)	21 cycling 23 control (M)	10 h/wk 4 h/wk	15–21	Cross-sectional	Lower BMD of the hip, leg and pelvis of cyclists *versus* control
Campion et al.[21] (2010)	30 cycling 30 control (M)	22–25 h/wk <1 h/wk	29 ± 3 28 ± 4	Cross-sectional	Professional cycling affected negatively BMD (femoral neck: −18%)
Penteado et al.[17] (2010)	31 cycling 28 control	21 h/wk	20–30	Cross-sectional	ND in BMD *versus* control
Barry et al.[10] (2008)	14 cycling (M)	>450 h/y	27–44	Two groups: low and high doses of calcium supplementation during one year	Both groups decreased BMD of the hip and sub-regions, regardless of calcium intake
Rector et al.[18] (2008)	27 cycling 16 marathon (M)	≥6 h/wk ≥6 h/wk	20–59	Cross-sectional	63% of cyclists had lumbar spine osteopenia and were 7-fold times more likely to have osteopenia

BMD, bone mineral density; F, female; h/wk, hours per week; h/y, hours per year; M, male; ND, no difference.

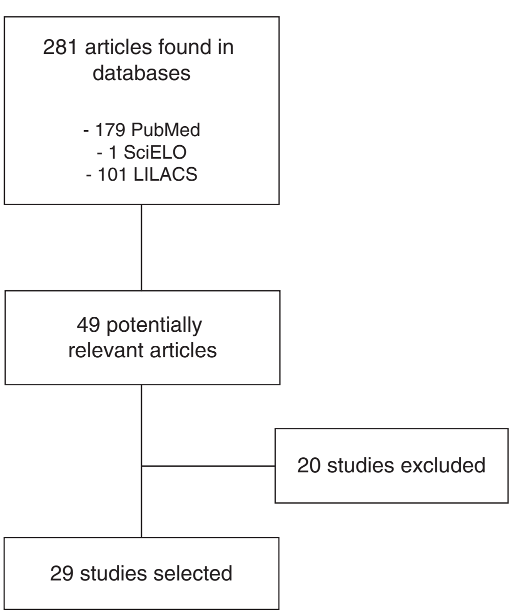

Fig. 1 – Flowchart for identification of studies included.

groups, and their findings showed no significant differences between groups.

Discussion

Cycling

Cycling is widely practiced as a non-weight-bearing, low-impact exercise; in addition the bicycle is used as a vehicle for millions of people in several countries, representing an important part of daily physical activity.[40] However, professional cycling, or even cycling carried out with a high training volume, is associated with low levels of BMD, increasing the likelihood of developing osteoporosis and osteopenia.[10,13–21]

A study[10] examined BMD of amateur cyclists (regional-level competitors) divided into two groups: those supplemented daily with 1500 mg or 250 mg of calcium during the period of nine months of competition, and three months after the competitions. According to the results, after nine months of training and competition BMD decreased significantly in both groups in the hip and its sub-regions.

Table 2 – Studies evaluating the effects of swimming on BMD.

Author	Sample	Training time	Age	Study design	Results
Czeczelewski et al.[22] (2013)	20 swimming 20 control (F)	2.3 ± 1.2 training years	11–13	Longitudinal (3 years)	Both groups increased BMD of lumbar spine during a 3-year follow-up, despite insufficient intake of calcium by these groups
Ferry et al.[23] (2013)	26 swimming 32 soccer 15 control (F)	10 h/wk 10 h/wk	15.9 16.2 16.3	Longitudinal (8 months)	Swimmers <BDM *versus* footballers
Maïmoun et al.[24] (2013)	20 swimming 20 RG 20 AG 20 control (F)	14.5 h/wk 21 h/wk 20 h/wk 2.5 h/wk	10–18	Cross-sectional	Swimmers <BDM *versus* RG (except skull)
Maïmoun et al.[25] (2013)	24 swimming 24 RG 24 control (F)	>5 training years	11–18	Longitudinal (1 year)	RG >BMD *versus* swimming and control group. ND between swimmers and control in studied locations. ND in BMD between groups after one year
Andreoli et al.[26] (2012)	12 swimming 12 marathon 24 control (F)	30 h/wk 22 h/wk 2 h/wk	54–73	Retrospective	Total body BMD lower in the control group *versus* athletes. Marathon > BMD of lumbar spine *versus* control. Marathon > BMD of legs *versus* swimming
Czeczuk et al.[27] (2012)	11 swimming I 7 swimming II 11 control I 7 control II (F)	4.8 h/wk 6.3 h/wk 1.4 h/wk 0.6 h/wk	52 ± 3 63 ± 4 50 ± 2 60 ± 2	Longitudinal (1 year)	Swimming I and control I >BMD of both groups II. Swimming I and control I reduced BMD after one year (−2% and −2.8%, respectively)
Greenway et al.[28] (2012)	43 swimming 44 control (F)	>2 h/wk (last 5 years)	40 ± 8 44 ± 7	Retrospective	ND in BMD and calcium intake between groups
Hind et al.[29] (2012)	10 swimming 31 marathon 14 gymnastics 22 control (M)	>5 h/wk >5 h/wk >5 h/wk	18–35	Cross-sectional	Gymnastics and marathon >BMD *versus* control group
Ferry et al.[30] (2011)	26 swimming 32 soccer (F)	10 h/wk 10 h/wk	16 ± 2 16 ± 1	Cross-sectional	Soccer >BMD *versus* swimming in total body, lumbar spine and hip. Swimmers (F) consumed more calcium that footballers (F)
Silva et al.[31] (2011)	12 swimming 10 soccer 10 tennis 14 control (M)	17 h/wk 16 h/wk 15 h/wk	10–18	Cross-sectional	Swimming and control <BMD in the femur *versus* soccer and tennis. ND in BMD between swimming and control
Carbuhn et al.[32] (2010)	16 swimming 17 softball 10 basketball 7 volleyball (F)	–	19 ± 1 20 ± 1 20 ± 1 19 ± 1	Longitudinal (1 year)	Swimming <BDM *versus* other sports (pre- and post-season).
Gruodyte et al.[33] (2010)	24 swimming 49 SG 24 sprinter 23 gymnastics 17 CCS 33 control (F)	9 h/wk 5 h/wk 5 h/wk 9 h/wk 6 h/wk	13–15	Cross-sectional	Swimming <BMD in femoral neck *versus* gymnastics.
Kemper et al.[34] (2009)	13 swimming 13 resisted exercise	–	66 ± 5 61 ± 6	Experimental (6 months)	No changes in BMD after six months of intervention in either group.
Velez et al.[36] (2008)	43 swimming 44 marathon 87 control (M/F)	–	≥65	Cross-sectional	ND in BMD between swimming and control. Marathon >BMD of total body *versus* swimming and control
Magkos et al.[37] (2007)	26 swimming 43 water polo 30 control (M/F)	>3 h/day >3 h/day	17–34	Cross-sectional	Swimming <Total and leg BMD *versus* control.
Magkos et al.[9] (2007)	7 swimming (endurance) 9 swimming (sprint) 10 marathon 11 sprint 15 control (M/F)	>3 h/day >3 h/day >3 h/day >3 h/day	19 ± 2 21 ± 2 23 ± 4 23 ± 3 22 ± 3	Cross-sectional	Swimming <BMD of leg and body *versus* control

Table 2 – (Continued)

Author	Sample	Training time	Age	Study design	Results
Mudd et al.[38] (2007)	9 swimming 8 gymnastics 14 softball 25 marathon 8 sprinter 10 hockey 10 soccer 15 rowing (F)	–	20 ± 1	Cross-sectional	Swimming <BMD of leg *versus* other sports (except marathon and rowing).
Maïmoun et al.[39] (2004)	13 swimming 11 cycling 14 triathlon 10 control (M)	10 h/wk 10 h/wk 15 h/wk	18–39	Cross-sectional	ND in BMD between groups. Cyclists consumed more calcium *versus* control group.

CCS, cross-country skiing; BMD, bone mineral density; SG, sport game (basketball, volleyball, badminton); F, female; AG, artistic gymnastics; RG, rhythmic gymnastics; h/wk, hours per week; M, male; ND no difference; Sprinter, short distance runners >800 m.

Olmedillas et al.[16] evaluated the BMD of professional cyclists aged >17 *versus* <17 years. These groups had a mean training time of 2.7 and 4.4 years, respectively. The results revealed that both cyclist groups had lower BMD when compared to control groups. The authors suggested that professional cycling performed during adolescence may negatively affect BMD; this is due in part to a reduced acquisition of peak bone mass at this stage, since this is a non-weight-bearing, low-impact activity. Sherk et al.[19] followed professional female cyclists during one year; the main finding in this study was a loss of 1–2% of BMD of the hip after one year of training and competition. Another study indicated that this professional sports modality increases seven-fold the chances of early development of osteopenia.[18]

Another study followed master male cyclists for seven years; the results showed that this sport was associated with a decrease in BMD, accompanied by an increase in the risk of fractures resulting from potential falls.[15] According to these authors, coaches and health professionals who interact with professional cyclists need to promote alternative exercises like plyometrics, resistance training or other higher-impact activity as a complement to this modality, thus helping to minimize bone loss in this group.

The data referred to these studies suggest that cycling, particularly the professional modality, is associated with decreases in BMD even when the practitioners ingest adequate amounts of calcium.[10,17] Among the possible causes, one can mention that this is a non-weight-bearing, low-impact exercise, being usually conducted in an environment of high-volume of training. This factor is associated with an excessive loss of calcium through the skin during exercise and with an increased production of substances known to stimulate bone resorption, such as cortisol and pro-inflammatory cytokines (*e.g.*, interleukin-6).[10] Overtraining can also lead to low production of hormones with osteoblastic activity, such as estrogen and testosterone.[41]

Thus, professional cycling is not associated with an increase/maintenance of BMD. In this case, this activity should not be performed by osteopenic/osteoporotic individuals aiming at preserving/increasing BMD, since this sport does not have a positive effect on BMD. Additionally, coaches and exercise physiologists should indicate complementary activities that help in the control/maintenance of bone mass in professional cyclists.

Swimming

Swimming is a non-impact physical activity, and is usually recommended in the rehabilitation process and for special populations, mainly the elderly. For this reason, many studies have examined the effects of swimming as an adjuvant in the prevention and treatment of osteoporosis; however, these trials showed no evidence of positive effects of swimming on bone mass.[9,23–34,36–38]

Kemper et al.[34] evaluated the effects of swimming practiced three times a week for six months with intensities between 60 and 90% of heart rate reserve in postmenopausal older women; their results showed that there were no changes in BMD in the femoral neck and lumbar spine after this training period.

Mudd et al.[38] compared BMD of women athletes in various sport modalities. According to these authors, the swimmers had the lowest mean values of BMD in lower limbs when compared to athletes of other sports, for instance, gymnastics, hockey, football and short-distance runners.

An interesting study[9] found lower BMD values in swimmers' lower limbs *versus* sedentary individuals (−9.8%). However, when these authors divided the swimmers in endurance and sprint athletes, the endurance group showed BDM values even smaller in lower limbs compared to the control (−14.8%).

A study published by Brazilian investigators measured BMD of several adolescent male athletes (swimmers, tennis players and footballers) and of the control group. The main findings of this study demonstrated that swimmers and controls had lower BMD of the femur in relation to other sports.[31] According to these authors, impact exercises that place weight-bearing forces on the skeleton, such as soccer or tennis, are able to stimulate local osteogenesis (femur).

Other longitudinal studies[23,25,27,32] showed that even when swimming was carried out for long periods (one year), this method did not provide a positive effect on bone mass. Interestingly, comparative BMD between control group *versus* swimmers showed no significant intergroup difference.

Based on these findings, professional swimming, or even that practiced in a scenario of high-volume training, is an activity that does not promote increase in BMD, taking into account that that this is a non-impact physical activity. These results suggest that health professionals should not indicate swimming as a non-pharmacological tool to prevent or treat osteoporosis.

Limitations

In our study we evaluated the effects of cycling and swimming practice on BMD; however, some benefits of these activities, such as improved aerobic fitness, mitochondrial density, and balance, among others, cannot be ruled out. Most studies analyzed in this systematic review had cross-sectional design (specifically in athletes). It is also suggested that new randomized, controlled, longitudinal experimental studies be conducted to evaluate the effects of swimming and cycling on BMD, to improve our understanding on these results.

Conclusion

The results of this study indicate that cycling and swimming do not cause positive effects on BMD and, therefore, are not the most suitable exercises for the prevention and treatment of osteoporosis.

Conflicts of interest

The authors declare no conflicts of interest.

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