The BJSM PhD academy awards

The impact of different loading sports and a jumping intervention on bone health in adolescent males: The PRO-BONE study

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1. Aims (What did I do?)

The present thesis was part of the PRO-BONE study (Effect of a program of short bouts of exercise on bone health in adolescents involved in different sports) and aimed to:

i) Examine the cross-sectional differences on bone mass, bone geometry, texture and bone metabolism in adolescent males involved in osteogenic (football) and non-osteogenic (swimming and cycling) sports in comparison with an active control group.

ii) Identify the determinants of bone mass and geometry in adolescent athletes.

iii) Investigate how the longitudinal (12-months) participation in osteogenic and non-osteogenic sports affects bone development in adolescent male athletes.

iv) Conduct a randomised control trial and examine the effectiveness of a novel 9-month progressive jumping intervention programme to improve bone outcomes in adolescent male athletes involved in osteogenic and non-osteogenic sports.

2. Rationale (Why did I do it?)

Adolescence is a crucial period for bone development and exercise can enhance bone acquisition during this period of life. Sports can be osteogenic, such as football, and as non-osteogenic, such as swimming and cycling. Despite football, swimming and cycling being among the most popular sports globally, there is lack of evidence comparing the effect of these sports on bone status and development in adolescent males. Previous studies indicate that a jumping intervention can be effective to improve bone outcomes in prepubertal and pubertal children[1]. However, it is unknown whether a jumping intervention is effective in augmenting bone health in an adolescent male athletic population.

3. Methods (How did I do it?)

The PRO-BONE study had a longitudinal design and recruited 121 adolescent (12-14 years at baseline) male athletes who had ≥3 h/week of sport-specific training (37 footballers, 41 swimmers, 29 cyclists) and 14 controls (≤3 h/week in the previous sports). Participants were followed for 21 months **(Figure 1)** and the PhD included cross-sectional, longitudinal and randomised control trial studies following the protocol[2]. Bone outcomes were assessed using four different methods: 1) Dual energy X-ray absorptiometry (DXA) measurement of bone mineral density (BMD) and content (BMC) at lumbar spine, dual hip and total body; 2) Hip structural analysis (HSA) estimation of bone geometry at the femoral neck; 3) Trabecular bone score (TBS) evaluation of bone texture at the lumbar spine; 4) Quantitative ultrasound (QUS) evaluation of bone stiffness at both feet. Bone formation (PINP), resorption (CTX-I) and nutrition markers (total serum calcium and serum 25-hydroxyvitamin D (25(OH)D) were also analysed. Fitness was assessed using the 20 meter shuttle run test (20mSRT), counter movement jump (CMJ) and standing long jump (SLJ).

4. Findings (What did I find?)

The collective changes in TBLH BMC during the 21 months of the PRO-BONE study can be seen at **Figure 2**.The cross-sectional findings indicate that footballers have better bone status than swimmers, cyclists and controls (7 to 21 %), and that there were no differences in bone status between participants of non-osteogenic sports and controls [3]. Lean mass was the strongest determinant of bone outcomes, followed by football participation and height in adolescent male athletes [4]. The longitudinal findings show that bone mass (5 to 8 %) and geometry (4 to 10 %) is greater in adolescent male footballers compared to swimmers and cyclists after one year of sport specific training, and that there were no differences in bone development between non-osteogenic sports groups and controls [5]. After one year PINP was significantly higher in footballers and controls compared with cyclists and swimmers, and 25(OH)D was significantly higher in footballers and cyclists compared with swimmers and controls. A 9-month jumping intervention programme can induce significant improvements in BMC, geometry and stiffness in swimming and cycling intervention groups (4 to 13 %) compared to their sport-specific controls, but not in football intervention group [6] **(Figure 3)**. Following the intervention P1NP decreased in all non-intervention groups and in football intervention group. CTX-I decreased in swimming and cycling non-intervention groups while 25(OH)D increased in both non-intervention and intervention groups of cyclists and footballers. CMJ improved in swimming and cycling intervention groups (3.1 to 3.2 cm).

5. Impact and practical application

This PhD thesis contributed to the literature by showing that a jumping intervention can counteract the lack of osteogenic stimulus in adolescent athletes involved in non-osteogenic sports, such as swimming and cycling, which has practical implications for sports clubs, professional and athletes to improve bone health during adolescence.

6. References

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Legends of figures and images

Figure 1. PRO-BONE study protocol and 21-month PhD timeline including baseline measurements (M1), 1 year of sports training measurements – pre-intervention (M2) and post intervention measurements (M3). FOO: Football players; CYC: Cyclists; SWI: Swimmers; PJT: Plyometric Jump Training.

Figure 2. Changes in adjusted total body less head (TBLH) Bone Mineral Content (BMC) during the studied period in all groups. BMC was adjusted for lean mass and peak height velocity at each time point.

Figure 3. A) PhD student Dimitris Vlachopoulos performing a DXA scan on one of the PRO-BONE study participants. Parent and participant consent received to use the photo. B) DXA output with intervention improvements including Trabecular Bone Score of the lumbar spine values pre and post intervention.