



The Influence of Age and Sex on Balance Performance and Balance Trainability in Youth



Theoretical Background

What we know and what we don't know

- I. Balance performance can be subdivided into four different types (Fig. 1) which are fairly associated in adults, yet there is a void in studies investigating these associations in youth (Kiss *et al.*, 2018).

➤ **Does age affect associations between types of balance performance in youth?**

- II. The maturation, especially of central nervous structures plays an important role in the development of balance performance (Fig. 2), however there are inconsistent findings regarding the question whether this development terminates in childhood (e.g., Hatzitaki *et al.*, 2002) or continues into adolescence (e.g., Steindl *et al.*, 2006).

➤ **Does the maturation of balance continue into adolescence?**

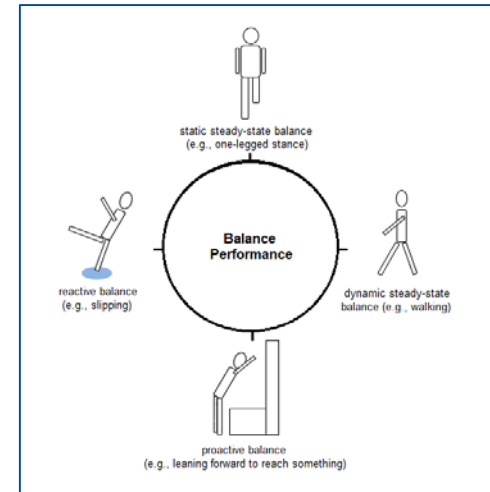


Fig. 1 Different types of balance performance according to Shumway-Cook & Woollacott (2007)

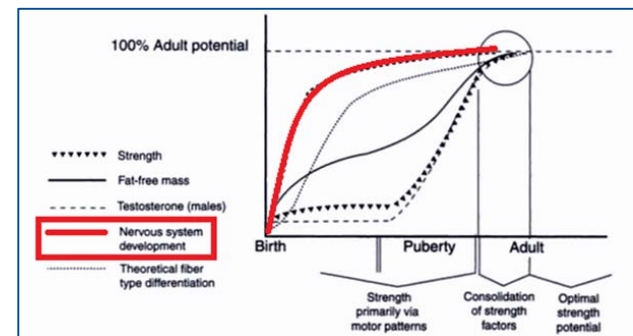


Fig. 2 Maturational processes according to Kraemer & Fleck (2005)

Theoretical Background

What we know and what we don't know

III. The earlier maturation of girls implies that they should show better balance performance than boys, however studies in this regard have reported equivocal findings (e.g., Steindl *et al.*, 2006; Libardoni *et al.*, 2017)

- Are there sex-related differences in balance performance in youth?

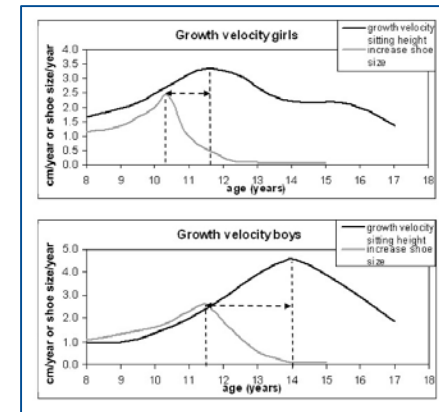


Fig. 3 Growth velocity of girls (top) and boys (bottom) (Busscher *et al.*, 2011)

IV. Balance is highly trainable in youth (Gebel *et al.*, 2018) (Fig. 4) as well as in adults (Lesinski *et al.*, 2015), however no study has compared the effects of a standardized balance training between children and adolescents and/or girls and boys

- Are there age-related and sex-related differences in the effectiveness of a standardized balance training?

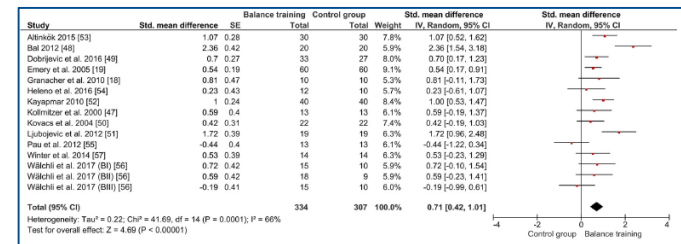
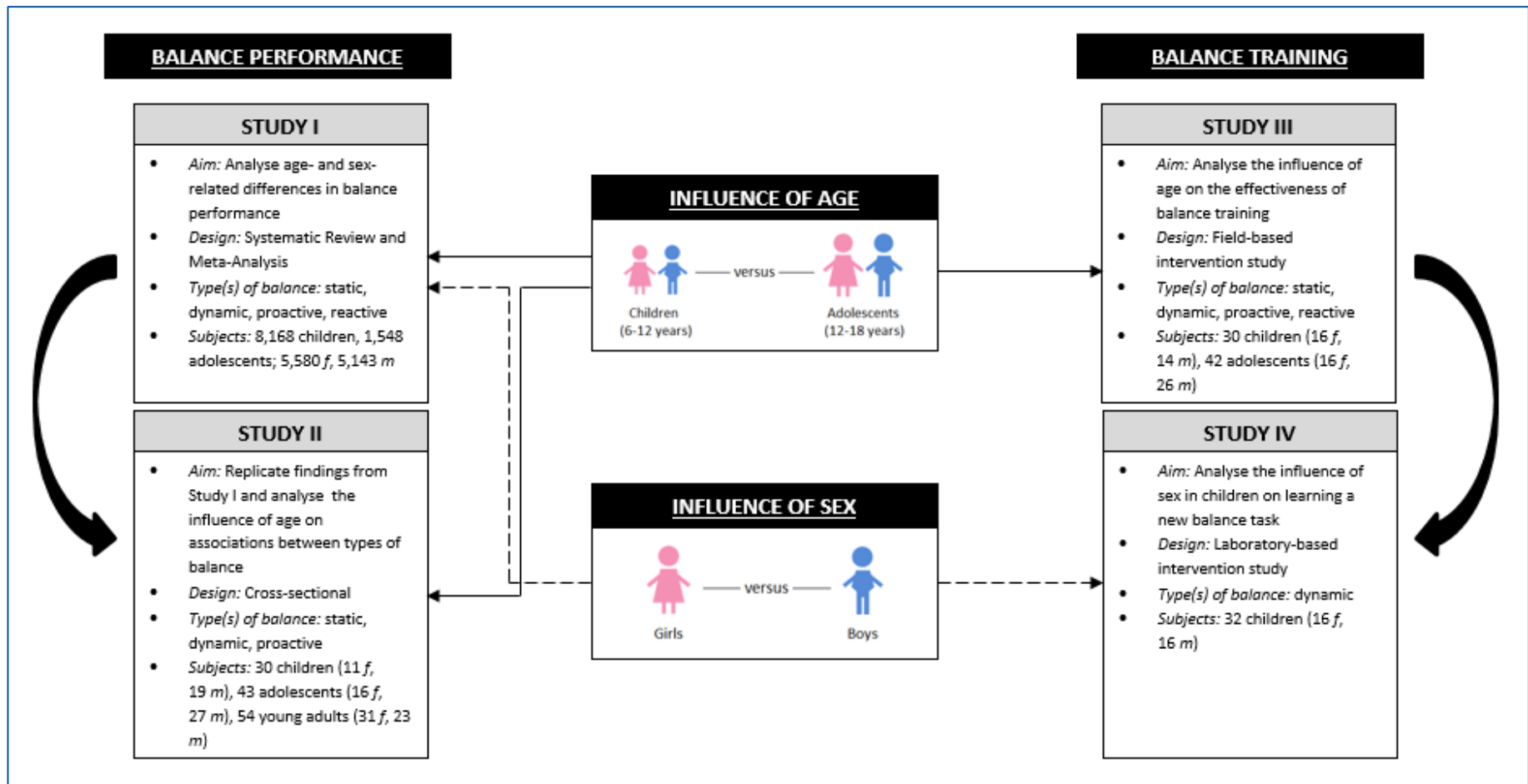


Fig. 4 Results of a Meta-Analysis on the effectiveness of balance training on measures of static-steady-state balance in youth (Gebel *et al.*, 2018)

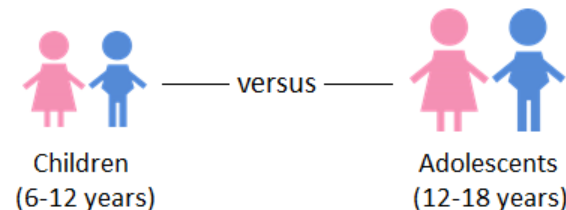
Methods

Theoretical Framework of the Cumulative Dissertation



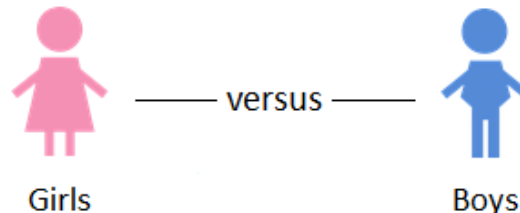
Results – Influence of Age

- **Associations** between static steady-state, dynamic steady-state and proactive balance are **small and non-significant irrespective of age group** (children vs. adolescents vs. young adults) [STUDY II]
- **Adolescents** show **superior static** steady-state, **dynamic** steady-state and **proactive balance** performance compared to children [STUDY I]
- **Older participants** (e.g., adolescents) largely showed **superior performances** compared to younger ones (e.g., children) [STUDY II]
- **Adaptations to balance training are in parts** (i.e., static/dynamic steady-state balance) **larger in children** compared to adolescents [STUDY III]



Results – Influence of Sex

- **Girls** show **superior static** steady-state **balance** performance compared to boys [STUDY I]
- **Negligible differences** regarding **dynamic** steady-state **balance** [STUDY I]
- **Boys** show **superior proactive balance** performance [STUDY I]
- During practicing **girls and boys improve** their performances [STUDY IV]
- Girls and boys show **learning effects** which **are significantly larger in girls** as compared to boys [STUDY IV]



Conclusions

- I. The maturation of balance does not terminate in childhood but continues at least into adolescence and there are sex-specific differences in balance performance, yet not exclusively to the favor of girls.
 - **Practitioners (e.g., coaches, physical education teachers) should pay attention to age- and sex-specific performance differences (e.g., when designing training programs)!**
- II. Irrespective of performance differences between different age groups (i.e., children, adolescents, young adults), associations between types of balance are overall small and non-significant.
 - **Types of balance should be trained and tested individually/complementary in these age groups!**
- III. The less-developed postural control system of children does not prevent adaptations to balance training but rather facilitates its effectiveness.
 - **In order to be most effective, balance training should be conducted already with children!**
- IV. Learning effects following the practicing of a new dynamic balance task are larger in young girls than in same-aged boys.
 - **Young boys may be given more practicing time than girls when learning a new balance task!**





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The Influence of Age and Sex on Balance Performance and Balance Trainability in
Youth | Simon Schedler | 01-26-2022



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