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Falls are common incidents, especially in older adults, and can have major consequences for the individual's health, quality of life and health care costs. The strongest risk factors of falls in community-dwelling older adults have been directly or indirectly associated to balance and gait impairments. Mediolateral (ML) balance impairment can cause incorrect ML weight shifting during standing and walking. Age-related decline in muscle strength, and proprioceptive and visual acuity may explain balance impairment in older adults. One muscle group that is important for ML balance control are hip abductor muscles, since they are involved in regulating ML postural sway and controlling lateral weight shifts. As hip abductor muscle function in terms of muscle strength as well as source of proprioceptive information might be affected by ageing, knowledge of hip abductor muscle function in ML balance control in older adults can be useful for the understanding of falls and the development of effective clinical interventions to prevent falls.

The aim of this thesis was to investigate the role of hip abductor muscle function in ML balance control in older adults. To this end, three main objectives through seven studies were addressed. The first objective focused on the question whether hip impairment following arthroplasty increases the risk of falling in older adults. In ***Chapter two***, a questionnaire study is described in which we investigated whether fall risk in older patients who had underwent a unilateral total hip arthroplasty (THA) had a higher risk of falling compared to patients who underwent a unilateral total knee arthroplasty (TKA) during the past 3-18 months. As predictor we defined the type of prosthesis, while outcome was set as the experience of at least one fall after surgery. The results revealed that 31% of the patients with a THA and 20% of the patients with a TKA fell at least once during the 3 to 18 months after surgery. Adjusting for confounding in logistic

regression analysis supported our hypothesis that older patients after a THA had significantly 1.93 times higher risk of falling than older patients after a TKA. These findings indicate that hip (muscle) impairment might negatively affect balance control more than knee (muscle) impairment.

The second objective focused on the question how ML balance is controlled in gait in older adults. We addressed the mechanical requirements for balance control in two experimental studies by restricting the ML base of support (i.e., by narrowing the step width) in both young and older adults (***Chapter three***), and by restricting the body center of mass kinematics (i.e., by wearing a trunk orthosis) in young adults (***Chapter four***). The findings of these two studies showed that both the ML center of mass kinematics (e.g., position and velocity) in ***Chapter three*** and the ML base of support (e.g., step width) in ***Chapter four*** were adjusted with respect to each other. The results of ***Chapter three*** also suggest that older adults have more difficulty to modulate their ML balance when they are forced to walk with narrower step width than young adults. This may occur during daily activities such as when they have to walk on a narrow path way or in a crowded environment.

Finally, the third objective regarding the role of hip abductor muscle function (e.g., muscle strength and proprioception) in ML balance control in older adults was addressed in four experimental studies. First, we developed and tested a reliable method to assess hip abductor proprioception in terms of hip joint position sense in a standing and active-active paradigm (***Chapter five***). Reliability of our test was substantial to almost perfect for the relative error (ICC values ranging from 0.81 to 0.93) and substantial (ICC values ranging from 0.71 to 0.81) for the absolute error in hip abduction, indicating that this method was sufficiently reliable to assess proprioceptive acuity of hip abductor muscles in older adults. Then, in ***Chapter six***, hip joint position sense and hip abductor muscle strength were investigated as possible limiting factors of ML balance control during ML weight-shifting tasks by tracking a predictable visual target, a predictable mechanical target and an unpredictable mechanical platform translation. The correlation analysis between balance performance indicators for these three tasks and hip abduction/adduction moment and moment rate showed that ML balance control in older adults requires substantial and fast hip moment generation. We also found that, regardless of predictability or unpredictability, hip abductor muscle strength mainly limited balance control when explicit visual feedback was presented. In addition, we showed that hip abductor proprioceptive acuity limited balance performance in platform translations, when explicit visual input was not available. In ***Chapter seven***, we experimentally manipulated unilateral hip abductor function by means of local fatigue to investigate whether this affected gait control and hip position sense in older adults. The results revealed that hip abductor muscle fatigue increased stride time variability and step-to-step asymmetry (partly due to slower mediolateral trunk movement in fatigued leg late stance towards the non-fatigued leg), yet gait stability in terms of the local divergence exponents was not affected by fatigue. Hip abductor muscle fatigue also decreased hip abductor proprioceptive acuity, in terms of absolute and relative error, in older adults. In ***Chapter eight***, we experimentally stimulated unilateral misinterpretation of hip abductor proprioceptive input by mechanical vibration of hip abductor muscles in standing and different phases of gait. The hip abductor vibration in standing resulted in ipsilateral hip abduction, a contralateral body weight-shift and trunk center of mass movement.

Vibration in early stance phase of gait led to downward pelvis tilt on the ipsilateral (vibrated) side, contralateral hip adduction and ipsilateral hip abduction and an increased trunk center of mass acceleration towards the contralateral side. Compared to early stance, late stance hip abductor vibration caused opposite kinematic changes, such as an upward pelvis tilt on the vibrated side, ipsilateral hip adduction and ipsilateral trunk center of mass acceleration. The increased trunk center of mass acceleration was compensated in the subsequent single-support phase during early stance vibration; whereas it was compensated in the subsequent double-support phase, which caused a decrease of the ML margin of stability during late stance vibration.

These results indicate that hip abductor proprioceptive acuity is important for regulation of ML balance in older adults.

In conclusion, as discussed in ***Chapter nine***, hip abductor muscle function is important for ML balance control in young and particularly in older adults and a decrease in force generating and proprioceptive function of these muscles can limit balance control and increase fall risk in older adults.