Summary

The aim of this thesis was to study the relationship between knee joint stability and functional ability in knee osteoarthritis (OA) patients. It has been stated that joint stability might be crucial for functional ability in knee OA patients. However, the evidence for this statement is rather weak, since knee joint stability studies in knee OA are limited. Knee joint stability has been defined as the ability of the joint to maintain a position or to control movements under different external loading conditions. Stability of the knee is provided by the passive restraint system (ligaments, capsule) and the active neuromuscular system (muscle strength, proprioception). More specifically, the way in which patients stabilize their knee depends on (i) the muscle strength, (ii) the laxity of ligaments and capsule of the knee, (iii) the accuracy of proprioception, and (iv) the varus-valgus motion during walking.

The overall research question of this thesis was: is knee joint stability a determinant of functional ability in patients with osteoarthritis of the knee? Three factors involved in the process of knee joint stabilization were the focus of the studies described here. Firstly, knee joint laxity was studied, with the following research questions:

Is knee joint laxity of influence on the strength of the relationship between muscle strength and functional ability? (Chapter 2)

When measuring knee joint laxity in knee OA patients, what are the intra- and inter-rater reliability and the intra- and inter-rater agreement parameters? (Chapter 3)

Is knee joint laxity related to structural joint change (joint space narrowing and osteophyte formation) and joint malalignment in knee OA patients? (Chapter 4)

Is knee varus-valgus laxity higher in women than in men in knee OA patients? (Chapter 5)

Secondly, this thesis focussed on the following questions in relation to proprioception:

Is knee joint proprioception related to functional ability and does poor proprioception aggravate the impact of muscle weakness on functional ability? (Chapter 6)

When measuring knee joint proprioception in knee OA patients and healthy subjects, what are the inter- and intra-rater reliability and the inter- and intra-
rater agreement parameters? Additionally, what are the effects of variations in measurement procedure on measurement error? (Chapter 7)

Finally, varus-valgus motion of the knee joint was studied, aiming to answer the following questions:
Is varus-valgus motion of the knee a valid measure of knee joint stability? (Chapter 8)
Is high varus-valgus motion associated with reduced functional ability in knee OA patients? Furthermore, in knee OA patients with high varus-valgus motion, is muscle weakness associated with a more severe reduction in functional ability than in knee OA patients with low varus-valgus motion? (Chapter 9)

Our first aim was to examine the influence of joint laxity on the relationship between muscle strength and functional ability (Chapter 2). Joint laxity has been defined as the displacement or rotation of the tibia with respect to the femur in the varus-valgus direction. Previous studies have shown that the relationship between varus-valgus laxity and functional ability is weak. In this thesis it was hypothesized that in knee OA patients with high knee joint laxity the relationship between muscle strength and functional ability is stronger than in knee OA patients with low knee joint laxity. This hypothesis was based on the assumption that in knee OA patients with high laxity, muscle activity has a dual role. Muscles around the knee compensate for the absence of stability due to impairments of the passive restraint system. The other role is that muscles influence directly functional ability. Taking on this dual role the importance of muscle strength increases for adequate functioning, which is reflected in a stronger relationship between muscle strength and functional ability. In our study it was shown that the interaction between muscle strength and laxity contributed to the variance in functional ability. Therefore, it was concluded that knee OA patients with high knee joint laxity and low muscle strength are most at risk of being disabled.

In Chapter 3 the clinimetric characteristics of the measurement of joint laxity were described. From literature, a device was constructed to measure knee joint laxity. Movement in the frontal plane was assessed in an unloaded situation, with relaxed muscles around the knee. An external load was applied at the knee in the varus-valgus direction what resulted in a movement in the
frontal plane. This measurement showed adequate reproducibility, where reproducibility consisted of reliability and agreement parameters. Although reliability was adequate, measurement error was rather high. Therefore, the measurement of laxity seems to be restricted to group assessment in research rather than for the assessment of individual patients in clinical practice. To reduce measurement error in the individual patient assessment, the number of measurements needs to be increased.

In Chapter 4 we assessed the relationship between radiological OA (ROA) features of the knee and joint varus-valgus laxity in patients with OA of the knee. Joint Space Narrowing (JSN) and osteophytes were assessed for every compartment of the knee. The study showed that OA knees with a reduction in joint space were significantly more lax than knees without reduced joint space. There was no significant relationship between osteophyte formation and joint laxity. Malaligined knees were significantly more lax than aligned knees. It was concluded, that these results support the idea that biomechanical factors play a role in the degeneration of the OA knee joint.

In Chapter 5 the difference in varus-valgus laxity between women and men was assessed. The results showed that women with knee OA have higher varus-valgus knee laxity than men with knee OA. It was concluded that gender is a potential source of bias when analyzing varus-valgus laxity data in knee OA.

In Chapter 6 we examined the relationship between proprioception and functional ability and the influence of joint proprioception on the relationship between muscle strength and functional ability. Knee joint proprioception encompasses the sense of joint position and the sense of joint motion. In our study we focused on the sense of joint motion. Proprioception was measured as the threshold for detection of knee joint motion, expressed as the joint motion detection threshold (JMDT). It was found that poor proprioception (high JMDT) was related to a greater reduction in functional ability. The interaction between proprioception and muscle strength was significantly related to functional ability. This means that in the absence of adequate motor control through a lack of accurate proprioceptive input, muscle weakness has a greater effect on a patient’s functional ability.
In Chapter 7 we assessed whether the measurement of knee joint proprioception is reproducible in knee OA patients and healthy subjects. We measured joint motion sense in a joint motion detection task. The reproducibility of the knee joint proprioception measurement in both populations was good. An additional aim was to assess the effect of variations in the measurement procedure on measurement error. The original measurement and two variations in measurement showed comparable measurement errors for knee OA patients and for healthy subjects. It was concluded that in knee OA patients and healthy subjects the absolute measurement error was rather high. Therefore, this measurement has limited value in the assessment of individual patients in clinical practice, but can be recommended for scientific research in groups of patients. To reduce measurement error in the individual patient assessment, the number of measurement repetitions needs to be increased.

In Chapter 8 it was studied whether knee varus-valgus motion during gait is a measure of joint stability in knee OA patients. For this purpose, we determined the validity of varus-valgus motion as a measure of knee joint stability by assessing the relationship of varus-valgus motion to muscle strength, joint proprioception, joint laxity and skeletal alignment in knee OA patients. However, it was found that varus-valgus motion was not related to muscle strength, joint proprioception, joint laxity or skeletal alignment. We concluded that joint stability is not an entity and should be regarded as a process, involving a number of factors.

In Chapter 9 we assessed the relationship between varus-valgus motion and functional ability in knee OA patients. Additionally, we assessed the impact of varus-valgus motion on the relationship between muscle strength and functional ability in patients with osteoarthritis of the knee. It was hypothesized that high varus-valgus motion of the OA knee during walking may cause difficulties in carrying out physical tasks in which knee function is pivotal and therefore may predict reduced functional ability. This would imply that muscle weakness leads to more severe functional disability in patients with high varus-valgus motion than in patients with low varus-valgus motion. Our results showed that in patients with high varus-valgus range of movement in the
loading response phase of the gait-cycle, muscle weakness was associated with a stronger reduction in functional ability than in patients with low varus-valgus motion. A pronounced varus position in midstance of the gait-cycle and a difference between the left and right knees in varus-valgus position in midstance were also related to reduced functional ability. Therefore, it was concluded that knee OA patients with high varus-valgus motion in the loading response phase and muscle weakness are more at risk of suffering a reduction in their functional ability. Furthermore, it was concluded that knee OA patients with more pronounced varus knees in midstance during walking show a stronger reduction in functional ability than patients with less pronounced varus knees or with valgus knees.

A general discussion of the results in this thesis was presented in Chapter 10. In this chapter the main results of the studies were discussed concerning the relationship between joint stability and functional ability in knee OA patients. Critical issues concerning the relationship between knee joint stability and functional ability in knee OA patients were featured. The reproducibility of the measurement of knee joint laxity and the reproducibility of the measurement of knee joint proprioception were discussed. As were discussed some implications for the usefulness of these measurements for clinical practice. Further, it was recommended to measure knee joint laxity and knee joint proprioception in large groups of healthy subjects to construct databases with reference values for future research. Implications for clinical practice were discussed in the direction of optimization of exercise therapy, in particular in the improvement of knee joint stability. Implications for physiotherapy education, particularly the training of physiotherapy students from concepts of Evidence Based Practice were considered. Finally, some implications for future research were given. The main recommendation was to establish the effect of knee joint stability training as part of an exercise program in an experimental longitudinal study.

The overall conclusion in this thesis was that joint stability is related to functional ability in knee OA patients. It was also concluded that joint stability should be regarded as a process, involving a number of factors. These factors, i.e., laxity, proprioception and varus-valgus motion during walking, influence functional ability and/or the relationship between muscle strength and
functional ability in knee OA patients. This may indicate that in addition to the well-established aim of enhancing muscle strength, exercise therapy could aim at enhancing knee joint stability: improved motor control might compensate for knee joint laxity, poor proprioception or varus-valgus motion during walking, which results in enhanced functional ability in knee OA patients.