All of the subjects involved in this study were sub-acute stroke survivors with one subject suffered from stroke just for six days and the longest one was around three months. They were all under active rehabilitation. Their mean balance (BBS) score was $43 \pm 3$ (range: 35-48). This indicated that they could walk unaided on level surfaces without manual contact from other person but require one person for standby guarding for safety purpose. This score is in consistent with the score reported by Stevenson in 2001. Stevenson (2001) assessed the balance performance of stroke patients under active rehabilitation who walk with or without walking aids and reported that the range of BBS score in independent walker was 45.3-51.8, in supervised walker was 38-45.3 while for assisted walker was 25.5 to 43. Similar findings were reported by Au-Yeung, Ng & Lo in 2003. They found stroke patients with an onset of stroke less than one year able to walk with or without a walking aids got $29.3 \pm 4.9$ in BBS needed supervision, whereas $46 \pm 2.9$ in BBS could walk independently.
Moreover, the BBS score, 43 out of 56 in this study, also indicated this group of patients may have higher risk of fall because Bogle Thorbahn & Newton (1996, cited in Stevenson, 2001) reported that BBS scores less than 45 predicted falls in elderly individuals with 53% sensitivity and 93% specificity. Similarly, a one year prospective study done by Muir, Berg, Chesworth & Speechley in 2008 reported when BBS was used as a multilevel tool rather than a dichotomous tool, likelihood ratios demonstrated a clear gradient of risk for fall outcome in elderly people. The likelihood ratios indicated that risk of fall increased with the BBS below a score of 45 and significantly increased if the score is below 40. Therefore, clinically, the subjects in this study were the right person to be considered to prescribe with walking aids to improve their ambulation stability.

4.1 Ground reaction force

There was a 4.9% and 5.7% difference of the mean GRF in mid-stance phase over the paretic and non-paretic limbs in walking unaided and with stick respectively, but these difference was proven to be statistically non-significant. In walking with quadripod, significant lower mean GRF over the paretic limb was found. It is in consistent with the definition of asymmetry (difference between the two lower limbs was more than 6%). Therefore, asymmetry weight bearing pattern was only found in walking with quadripod in this study. The mean GRF in mid-stance phase of the paretic limb was 10.7% less than the non-paretic side. It means that the subjects put
less weight, around 80 Newton, on their paretic limb when compared with the non-paretic limb while walking with quadripod.

Moreover, the mean GRF over the paretic limb in mid-stance phase in subjects who walk with quadripod was significantly lower than walk unaided but no difference was found on the non-paretic limb. These results indicate that walking with quadripod significantly encourages less weight bearing on the hemiplegic limb but no effect on the weight bearing over the good limb. Therefore, we confirmed that only small amount of force (around 10.7% of the mean GRF) was transferred to the quadripod during walking in subacute stroke patients. These findings are similar to the results of Laufer (2002). However, in contradict to Laufer’s (2003) result but agree to Laufer’s (2002) result, the weight shifted to the quadripod in this study was found to be from the paretic limb rather than the non-paretic limb.

Moreover, walking with stick may also have the tendency to encourage less weight bearing on the paretic limb but statistically was proven to be non-significant. Therefore, further study with large sample size should carry out to clarify this phenomenon.

Therefore, it is reasonable to suggest intensive unaided gait training to maintain or encourage a symmetrical weight bearing pattern for mild to moderate severe stroke survivors who are under active rehabilitation.

Unexpectedly, the symmetry weight distribution was found between the paretic and non-paretic limbs in stroke survivors in this study in unaided and stick walking.
These results are in contradicted to previous results of Laufer (2003). It may due to the difference of the study design and characteristics of the subjects. Previous results were obtained from static standing, whereas result from this study was obtained from walking. Furthermore, the cases involved in this study were mild to moderate severe sub-acute stroke survivors. It is possible that greater weight bearing asymmetry will find in more severe stroke survivors because of their strong relationship (Tyson 1998).

4.2 Temporal symmetry

In consistent with previous studies (Wall & Turnbull, 1986; Von Schroeder et al, 1995; Chen et al, 2004 & Patterson et al, 2008), the swing and stance symmetry values shows that all subjects in this study presented with a typical hemiplegic gait pattern in temporal symmetry aspects: prolonged swing phase and decreased stance phase. They spent more time in swing phase of the paretic limb. It may be due to insufficient joint excursion of hip, knee, and ankle; decreased co-ordination or impaired sensation of the paretic limb then results in more time to allow compensation or trick movement (pelvic tilting, hip hiking, hip circumduction…etc.) to lift up the limb and clear it from the floor (Chen et al 2003). Similarly, poor motor control results in poor stability of the paretic limb to maintain a reasonable normal time in single support phase.

The results of overall temporal symmetry values were similar as recently
reported by Patterson et al (2008). But higher percentage of the subjects in this study was presented with overall temporal asymmetry (74% versus 61.1% in Patterson et al, 2008). It is possible that the condition of the subjects involved in this study was still sub-acute and still need supervision in ambulation while the subjects in Patterson et al’s study in 2008 were more chronic and could walk with or without walking aids independently. It means the subjects in this study still have potential to improve in different aspects. In addition, the variation of the overall temporal symmetry values in this study is also large. The values vary from 1.12 to 5.87 with the subjects belonged to similar functional ambulation class (supervised walker). These results were consistent with Wall & Turnbull (1986) and Patterson et al (2008). It indicates that temporal symmetry values in stroke survivors with similar functional ambulation class can vary a lot.

According to Patterson et al (2008), it is easy for physiotherapists to consistently detect the presence of temporal asymmetry among people with severe asymmetry (symmetry index greater than or equal to 1.5) by clinical observation. But for symmetry values between 1.1 and 1.5, mild asymmetry, it is more difficult to detect through observational approaches. In this study, among all the overall temporal asymmetry subjects, half of them presented with mild asymmetry. Therefore, it seems a measurement of temporal symmetry in clinical assessment may assist the physiotherapists to have a better picture of the gait of the patient and also help to monitor their progress.
Another important finding in this study is that there has no statistical significant difference in all temporal symmetry values between walking unaided and walking with walking aids (stick or quadripod). It indicates walking aids has minimal effect on temporal symmetry when compare with unaided walking.

4.3 Gait speed

The self–selected comfortable walking speed is specific to each person and has been proved to be negatively correlated with the severity of the stroke and the motor control (Tyson, 1998; Chen et al, 2003). Although all the subjects in this study were classified as supervised walkers, their self-selected comfortable gait speeds were varied a lot with a range from 0.08 to 0.77m/s in walking with or without walking aids. The mean values ± standard deviation was 0.43 ± 0.18 m/s for walking unaided, 0.40 ± 0.16 m/s for walking with stick and 0.39 ± 1.4 m/s for walking with quadripod. These are similar to the speeds reported by Buurke et al (2005) but much lower than normal gait speed. (1.07 ± 0.17m/s by Von Schroeder et al in 1995 and 0.94m/s by Kuan et al in 1999). According to Perry et al (1995), these gait speed indicates moderate gait impairment and be classified as limited community ambulation group.

Walking with both stick and quadripod were found to be significant slower than walking unaided. No effect was found in types of walking aids. It may be due to extra time need to manipulate the walking aids forward. This result is in consistent
with results of Chen et al (2000). Similar self-selected comfortable speed was found and walking with assistive device was proved to be slower than unaided walking. But the result is different from the result found by Kuan et al in 1999. It is possible that their sample size is very small and their patient belonged to severe gait impairment group with a mean self-selected speed of 0.29± 0.19m/s which was smaller than 0.4m/s.

4.4 Relation between ground reaction force and gait speed

In this study, there was a modest positive correlation between gait speed and GRF for the paretic limb in walking with quadripod\(r=0.445, p=0.014\) only. It is different from the high correlation found by Kim & Eng (2003). They reported that the correlation between gait speed and Symmetry index of GRF was high, whereas \(r = 0.686\). It may be due to their subjects were chronic stroke case and no walking aids were used in their assessment. But both of the studies indicate faster speed in walking will result in better weight distribution over the paretic limb. It is because the patients walk with faster self-selected speed present with less lateral movement of the pelvis and more lateral symmetry in walking, therefore, more weight will bear on the paretic limb. This lead to the question that the patient walk with quadripod presented with less weight distribution over the paretic limb in this study was due to the effect of the quadripod or the gait speed. Therefore, further study with similar walking speed to rule out the effect of walking aids is suggested.
4.5 Relation between Gait speed and temporal symmetry

Modest negative relationships were found between self-selected walking speed and absolute temporal symmetry for all the three walking conditions: unaided walking, stick walking and quadripod walking. It means no matter using walking aids or not, slower walking speed will result in a more asymmetry gait pattern temporally. The current results were in consistent with previous results by Patterson et al (2008) and Kim & Eng (2003). Patterson et al (2008) found similar correlation between the gait speed and the overall temporal symmetry value ($r= -0.528$ to $-0.578$ in this study versus $r = -0.583$ in Patterson et al’s study). Kim & Eng (2003) found that the correlation between the degree of asymmetry in swing time and gait speed was similar ($r = -0.57$).

As mentioned before, the overall temporal symmetry value indicates an increase in swing time and a decrease in stance time of the paretic leg. The impairment of prolonged swing time was suggested due to insufficient muscle power to lift up the paretic leg and swing it forward. Faster gait speed would lead to a decrease of time to allow the paretic limb to swing through. It also favors the paretic limb to have a shorter time in single stance phase. Therefore, faster walking speed results in more symmetrical gait pattern.

However, this result cannot explain the interesting findings mentioned before why the percentage of overall temporal asymmetry in walking unaided was less than walking with stick and quadripod. It may be due to as stated by Tyson & Ashburn in
1994 that the more severity stroke patient was benefited from walking aids. Therefore, further study with adequate number of severe stroke subjects to rule out this finding is suggested.

4.6 Clinical implication

Firstly, walking with quadripod do have the effect to decreased weight bearing on the paretic limb for around 5.8 and 5.0% and proved to be asymmetry when compared with unaided and stick walking respectively in mild to moderate severe sub-acute stroke patients who are under active rehabilitation. Therefore, to facilitate a symmetry weight bearing gait pattern to prevent bone loss after stroke, to avoid using quadripod during active gait training in this group is highly recommended. Moreover, to relearn to walk as soon as possible after stroke is also advised because Jørgensen et al (2000) confirmed that the time the patients started to walk also statistically significantly affected the one year change in BMD in the lower femoral neck on the paretic limb.

Although quadripod was proved to have negative effect (decreased weight bearing on paretic limb) on hemiplegic gait pattern, it’s effect on walking stability, self confidence in walking and other potential good effects can not be ignored. Besides the consideration of the walking aids’ effect on weight bearing symmetry, there are still many other factors should take into account to determine whether a
stroke patient is fit to be prescribed with walking aids or not. These factors include severity of the stroke, patient’s cognitive function, judgment ability, walking stability, muscle strength and endurance in manipulating the walking aids, his/her living environment and other medical conditions. Therefore, for patients with mild to moderate severe stroke, when their progress in rehabilitation was become static and was judged by his/her physiotherapist that he/she will not able to walk without an walking aids in long term, then it is acceptable to prescribe him/her with appropriate walking aids to allow him/her to ambulate more independently and safely. For patients with a more severe stroke, walking aids may offer a mechanical advantage to them because Tyson & Ashburn (1994) found that the gait performance of this group of people when using walking aids was better than no aids. Apart from mechanical advantage, it is possible that walking aids may help stroke survivors to increase confidence, decrease energy expenditure and fatigue in walking and also increase awareness of disability from other people. Further study to explore the effect of walking aids on weight distribution of patient who rely on walking aids is suggested. Moreover, to assess the benefits of using walking aids from the stroke patient’s point of view will also assist in clinical prescription of walking aids.

Secondly, sub-acute patients who have just learnt to use walking aids were proved to walk slowly than walk unaided. Therefore, for stroke survivors cannot avoid the use of walking aids, further training on gait speed is also suggested since faster speed is more functional and result in better weight bearing symmetry.
Finally, apart from avoid early prescription of walking aids to achieve a more symmetry gait in hemiplegic gait in stroke patients, strengthening exercise to hip, knee flexors and ankle dorsiflexors, single-support stability training, overall balance training, gait training with a faster gait speed, weight shifting exercise…etc can not be excluded. It is because there has significant relationship between gait and balance, weight-bearing ratio, motor control and normalized strength of the paretic lower limb (Bohannon, 1987).

4.7 Limitations

First of all, the sample size is small. Then due to the convenience sampling and the subjects in this study belonged to a specific group of mild to moderate severe sub-acute stroke patients who could walk unaided but need supervision to prevent fall. Therefore, any generalization must be treated with caution. Further investigation is required with large sample size, a wider range of severity of sub-acute stroke patients. Moreover, other factors such as site of stroke, hemiplegic side, motor control of the affected limbs, sensory deficit, co-ordination problems…etc should also take into consideration because all these values may affect the mean values of gait parameters. In addition, the placement and placing sequence of the walking aids during walking were not standardized in this study. It may also have profound effect on the gait parameters.