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DIPLOMARBEIT

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„The Effect of Rest and Activity Schedules on Sleep:
A Comparison of Free Days and Work Days“

verfasst von

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1. Introduction

Getting enough sleep is important for a lot of reasons. Sleep deprivation can have negative effects on a wide range of physiological, psychological and cognitive functions (Borbély *et al.*, 1981; Durmer & Dinges, 2005; Van Someren & Riemersma-Van Der Lek, 2007). Nonetheless, sleep deprivation is not a direct effect of time spent in bed. It is more affected by the structure and progression of sleep during the resting phase. Many environmental and experiential factors can disrupt sleep (Owens & Matthews, 1998; Wilcox et al., 2000; Freedman et al., 2001). In particular, it is known that those factors that reduce REM (rapid eye movement) sleep quality and amount can produce the strongest sleep deprivation effects (Agnew et al., 1967; Tufik et al., 1978; Karni et al., 1994). In effect, one might have more overall sleep time but this does not necessarily imply that adequate amounts of REM-sleep were present. The effectiveness of REM is also dependent on preliminary slow wave sleep (Stage 2 and Stage 3 sleep). These sleep phases are also very sensitive to environmental manipulations and circumstances (Brunner et al., 1990).

There are well-known parameters and markers to describe sleep. One is sleep efficiency. It is a measure of the overall sleep quality and the opposite end of the scale associated with sleep deprivation. It can be monitored with actigraphic recordings or with electroencephalography.
Another is subjective sleep quality. This is a measure of the perceived sleep efficiency and has also been shown to correlate with objectively measured sleep efficiency (Akerstedt et al., 1994; Kushida et al., 2001).
This markers were used in this study, in which the subjects all had individually scheduled days off ("free days") and individually scheduled work days.
The sleep analysis was carried out in two parts: individually scheduled free days versus individually scheduled work days on the one hand and calendar work days (with the night from Sunday to Monday separate, due to the assumed lag between weekend and workdays) versus calendar weekends.
In western cultures sleep schedules are often manipulated against the wishes of the sleeper for economic, employment or social reasons. In fact, the manipulation has become a standardized practice in society with a five day work week and work free weekends.

For this reason a study was conducted on subjects over a number of years to determine how changes in sleep time, sleep efficiency and subjective sleep quality paralleled the culturally induced shifts in activity and rest from free days to work days. The subdivision into individually scheduled free days versus individually scheduled work days on the one hand and calendar work days versus calendar weekends allowed us to see if people who do not have the same work days and free days as the social norm still show some kind of connection to calendar work days or free days. If there was a connection this might mean that subjects sleep less on calendar work days and more or better on calendar free days even if these days do not correlate with their own free days and work days.
The idea to look at this has been undertaken by other authors who described so-called weekend-effects (Wittmann et al., 2006).
Social jetlag (also called weekend-effect) is the effect of constant sleep deprivation over the work days and sleep catch-up over the free days.
The observation of students with individual schedules opened up the opportunity to see if they displayed social jetlag like many children (Epstein et al., 1998), teenagers (Szymczak et al., 1993; Hasler et al., 2012) or even adults with strict work schedules or certain chronotypes (Wittmann et al., 2006).

In addition to the work day versus free day issue, it was also important to consider gender as a confounding issue. Differences between the sexes in weekend effects have been described by other authors (Díaz-Morales & Sánchez-López, 2008; Tsai & Li, 2004). Studies have further documented how men and women handle sleep deprivation differently (Armitage & Hoffmann, 2001; Blatter et al., 2006; Cappuccio et al., 2007).

The questions that were tried to be answered with this study were:
Question 1: Are there differences between sleep-quality on free days versus work days? And does sleep-quality differentiate on weekdays versus weekends?
Question 2: Are there differences between the "time spent in bed" (objective TIB) on free days versus work days? And are there differences between time in bed (objective TIB) on weekdays and weekends?

Question 3: Are there differences between the sleep efficiency (subjective and objective) on free days versus work days? And are there differences between the sleep efficiency (subjective and objective) on weekdays and weekends?

In evaluating these key issues sex differences were considered as well.

2. Methods

The subjects used in this study were 122 students. This group of individuals was unevenly divided, with roughly three quarters women (92 women versus only 30 men).
The age-range differed between genders. The female subjects consisted of over 90% of individuals between 20 and 27 (the 7 outliers were aged 19, 29, 30, 32, 37, 37 and 42), implying the mean age (without the ouliers) was 23,2.
The male subjects consisted of a slighlty older majority of 90% of individuals between 22 and 29 (the 3 outliers were aged 31, 31 and 48), implying the mean age (without the outliers) was 24,9.
The data used in this study was collected between March and May 2007, 2008, 2010, 2011 and 2012.
The study employed the use of Actiwatches™ in order to document sleep duration and efficiency objectively. Actiwatches™ are small actigraphs which had to be worn on the non-dominant hand. Actigraphs measure movements and therefore activity by detecting changes in position and acceleration.
Recorded data was analysed with "Actiwatch & Sleep Analysis 7.22" software, provided by Cambridge Neurotechnology Ltd. England. In addition to activity monitoring by actigraphs, participants had to fill out a sleep diary every morning and evening. The time period for collection ranged from between one to three weeks. The sleep diary consisted of a list of objective questions addressing the time spent in bed, the exact time of going to bed ("lights off") or leaving the bed ("lights on") and subjective ratings of tiredness or wakefulness.

For this study only a few parameters were analysed.
The first parameter was subjective sleep quality. It was measured by Visual Analog Scale (VAS).

The VAS is quite precise in assessing subjective data, as demonstrated in its use in acute pain measurement and the high reliability that was concluded from it (Bijur et al., 2008).
Since the students of 2007 used a different method of sleep quality assessment the sleep quality data from this year could not be used in this study.
The second parameter was the objective amount of time spent in bed, which was calculated by the actigraphic measurement.
The third and fourth parameters were the sleep efficiency.
Both the objective, actigraphically ascertained sleep efficiency and the subjective sleep efficiency were used. The sleep efficiency was calculated by dividing the amount of sleep time by the amount of time spent in bed, multiplied by 100.

Days were separated or classed according to the behavioural dictates of the post sleep phase, activity onset. There were official "free days". In addition there were days where the subjects had temporal obligations in the morning. These were classified as “work days”. Finally there was the calendar day-of-the-week where researchers maintain that everyone is under time pressure. Especially Mondays are thought to belong to this group.
For the statistical analysis, the program SPSS versions 15 and 21 were used.
The datasets for male and female subjects were analysed for normal distribution separately with the Kolmogorov Smirnov Test. Significances above $p=0.05$ indicate a normal distribution. All parameters except the time spent in bed for male subjects were not normally distributed. Hence nonparametric statistics were employed. Therefore, for a comparison between two groups the Mann-Whitney U-test was used and for comparisons between more than two groups the Kruskal Wallis test was used.

3. Results

3.1. Overall Dataset Characteristics

Table 3.1.1.: The number of individually-scheduled free or work days vs. calendar free or work days.

Table 3.1.1.		Weekday			
		Calendar Freeday	Calendar Workday	Night from Sunday to Monday	Total
Individually scheduled	Freeday	294	420	74	788
	Workday	235	617	170	1022
	Total	529	1037	244	1810

Table 3.1.1. portrays the number of individually scheduled free days and work days in relation to calendar free days, calendar work days, and nights from Sunday to Monday.
As can be seen, while many students worked on official work days and slept in on official free days, a high number of students worked on official free days and slept in on official work days as well. There seems to be only a weak connection between individually scheduled and calendar days for only the amount of time spent in bed (Table 3.1.4.).

The overall dataset analysis for sleep quality, sleep efficiency and amount of time spent in bed for all subjects is presented in Tables 3.1.2., 3.1.3. and 3.1.4.

Tables 3.1.2. - 3.1.4.: Basic statistics on sleep in all participants.
N refers to the number of nights that were included in the analysis. SQ is the sleep efficiency (VAS), TIB is the amount of time spent in bed (in minutes), SEa is the actigraphically measured sleep efficiency (in percent) and SEs is the subjective sleep efficiency (in percent). Significant differences were tested with the Mann-Whitney U-test for the difference between individually scheduled free days and work days and with the Kruskal Wallis Test for the

differences between the nights from Sunday to Monday (M or Monday), the other weekdays (the night from Monday to Tuesday (T), the night from Tuesday to Wednesday (W), the night from Wednesday to Thursday (Th) and the night from Thursday to Friday (F)) and the weekend (the night from Friday to Saturday (Sa) and the night from Saturday to Sunday (S)) and for the comparison between all the individual weeknights.

Table 3.1.2.		Work days	Free days	Significance of differences FD / WD
SQ	n	878	692	0.001
	MW ± SD	31,71 ± 23,42	28,26 ± 23,65	
TIB	n	1014	785	0.000
	MW ± SD	463,56 ± 90,18	499,19 ± 96,44	
SEa	n	1014	783	0.519
	MW ± SD	84,44 ± 7,90	84,56 ± 6,85	
SEs	n	947	744	0.009
	MW ± SD	91,00 ± 9,09	92,12 ± 7,98	

Table 3.1.3.		Monday	Other Weekdays	Weekend	Significance of differences WD / WE
SQ	n	208	907	456	0.659
	MW ± SD	29,42 ± 24,00	30,41 ± 23,23	30,02 ± 24,13	
	n	243	1038	527	

TIB	MW ± SD	484,77 ± 94,84	482,24 ± 90,84	470,60 ± 100,78	0.080
SEa	n	243	1039	526	0.931
	MW ± SD	84,39 ± 7,89	84,62 ± 7,24	84,32 ± 7,70	
SEs	n	227	978	491	0.702
	MW ± SD	91,14 ± 8,78	91,80 ± 8,02	91,04 ± 9,72	

Table 3.1.4.		M	T	W	Th	F	Sa	S	Significance of differences between days
TIB	n	243	249	258	266	265	265	262	0.046

There was a significant difference between individually scheduled free days and work days for sleep quality, amount of time spent in bed and subjective sleep efficiency. The sleep efficiency calculated by actigraphs was not significant.

In contrast, there was no significance in any parameters between the three blocks of nights from Sunday to Monday or other nights during the week and on the weekends. Since the amount of time spent in bed was not highly insignificant, additional comparisons between the nights during the whole week were performed (Table 3.1.4.). In this comparison there was a significance for the amount of time spent in bed.

3.2. Sleep Quality on Free Days versus Work Days

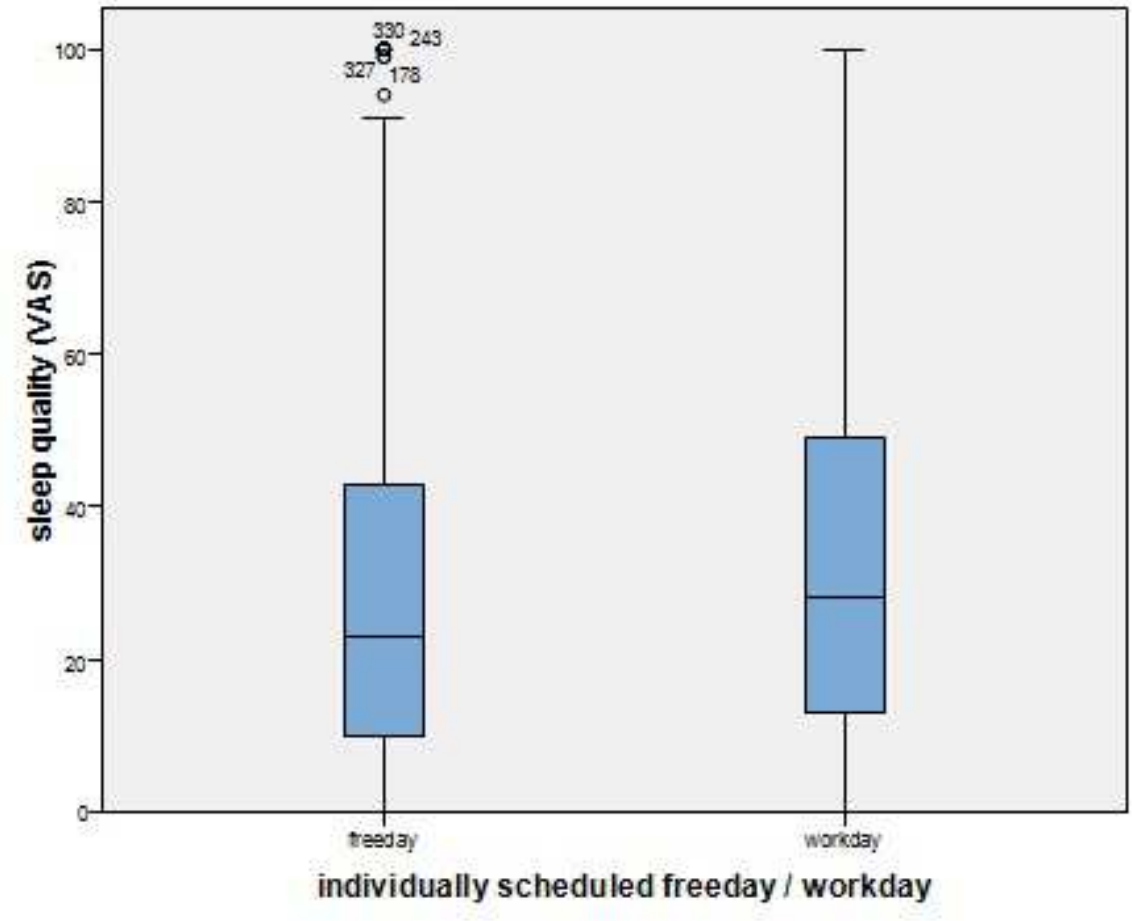

Fig. 3.2.1.: The sleep quality for all subjects on individually scheduled free days and work days. Boxes are comprised of the first quartile (bottom of the box; middle value between the smallest number and the median) and third quartile (top of the box; middle value between the highest number and the median). Horizontal bars show the second quartile (the median). The ranges are represented as vertical lines. Outliers are circles with individual identities. Shown here are the results from all observed nights.

In Figure 3.2.1., the sleep quality for all subjects has been plotted. The sleep quality was generally lower (better) on free days, with a wider range on work days. The differences between free days and work days were significant (p=0.001).

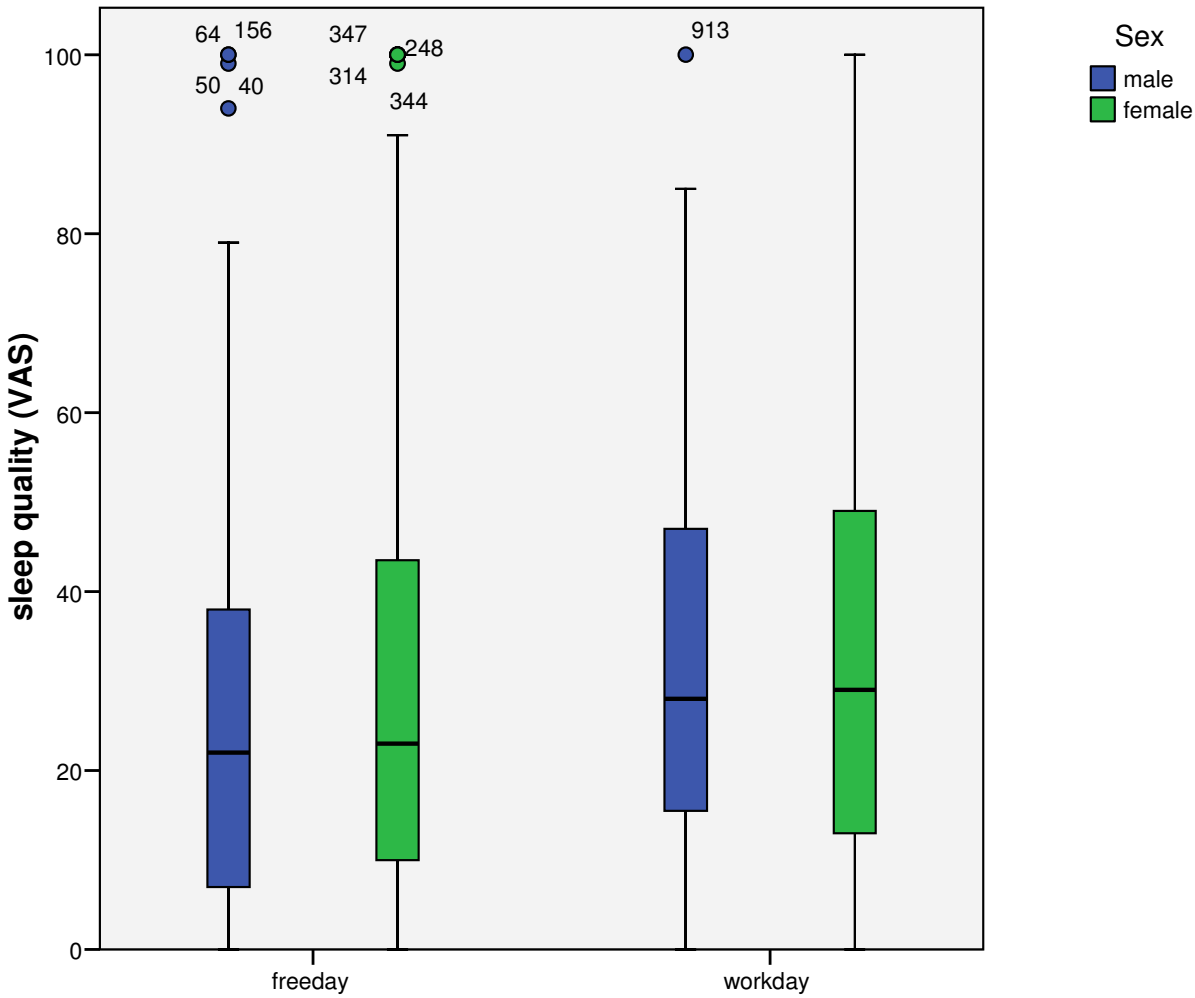

Fig. 3.2.2.: The sleep quality for male and female subjects on individually scheduled free days and work days. Boxes are comprised of the first quartile (bottom of the box; middle value between the smallest number and the median) and third quartile (top of the box; middle value between the highest number and the median). Horizontal bars show the second quartile (the median). The ranges are represented as vertical lines. Outliers are circles with individual identities. Shown here are the results from all observed nights.

The VAS estimates of sleep quality for male and female subjects are shown in Figure 3.2.2. Female subjects showed a wider range than male subjects although a few of the more extreme outliers were men. Male subjects had generally lower (and therefore better) sleep quality scores than female subjects. For both men and women the sleep quality was lower (better) on free days.

Table 3.2.1.: Descriptive statistics (sleep quality of male and female subjects) for individually scheduled work days and free days. N refers to the number of nights that were included in the analysis. The significant differences were tested with the Mann-Whitney U-test.

Sleep quality (VAS)		Work days	Free days	Significance of difference FD / WD
Male subjects	n	223	168	0.008
	MW ± SD	31,42 ± 22,57	26,33 ± 23,19	
Female subjects	n	655	524	0.015
	MW ± SD	31,80 ± 23,73	28,87 ± 23,78	

As can be seen in Table 3.2.1. the sleep quality on free days and work days differed significantly for both sexes (Mann-Whitney U-test: male subjects p=0.008; female subjects p=0.015).

3.3. Sleep Quality on Weekdays versus Weekends

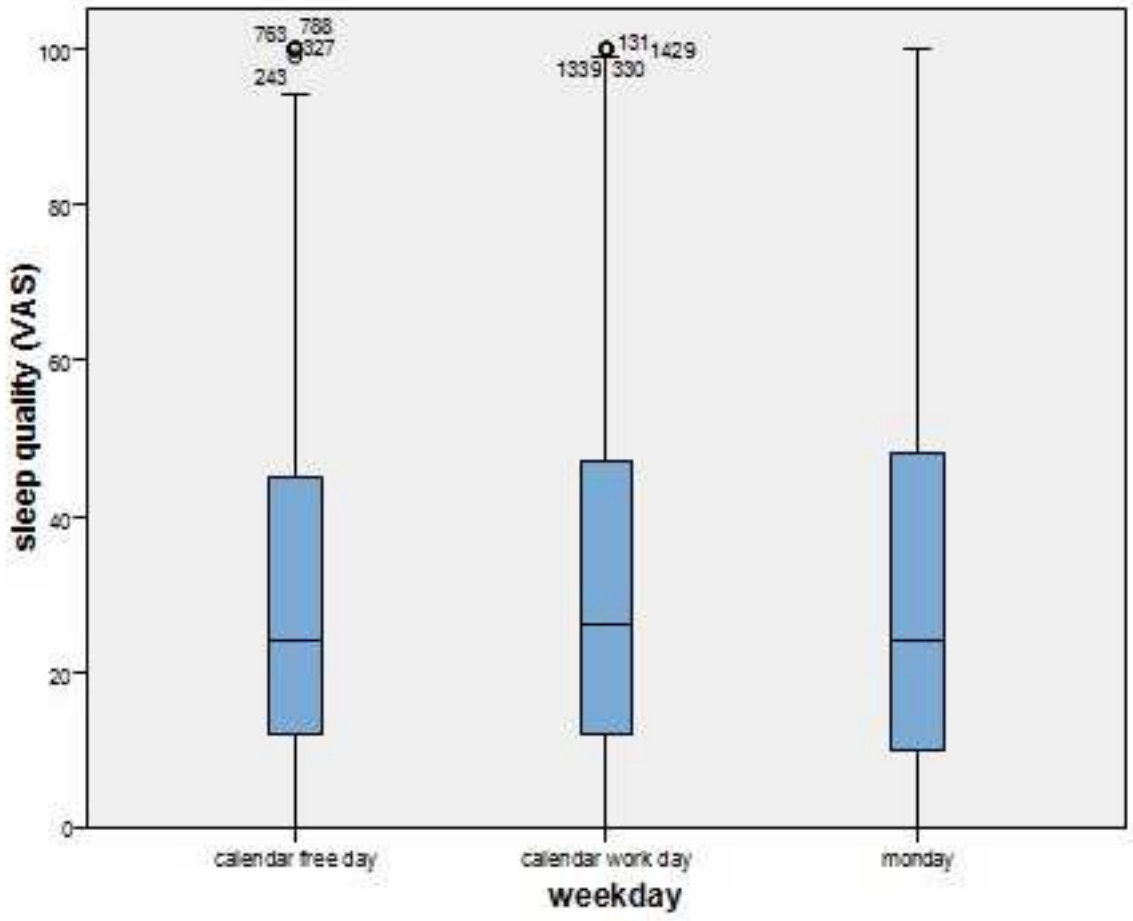

Fig. 3.3.1.: The graph shows the ratings for sleep quality for all subjects on calendar free days and work days and for the nights from Sunday to Monday. Boxes are comprised of the first quartile (bottom of the box; middle value between the smallest number and the median) and third quartile (top of the box; middle value between the highest number and the median). Horizontal bars show the second quartile (the median). The ranges are represented as vertical lines. Outliers are circles with individual identities. Shown here are the results from all observed nights.

The distribution of the subjective ratings of sleep quality on calendar free days and work days and the nights form Sunday to Monday for all subjects has been plotted in Figure 3.3.1. There were no significant differences between the weeknights ($p=0.659$).

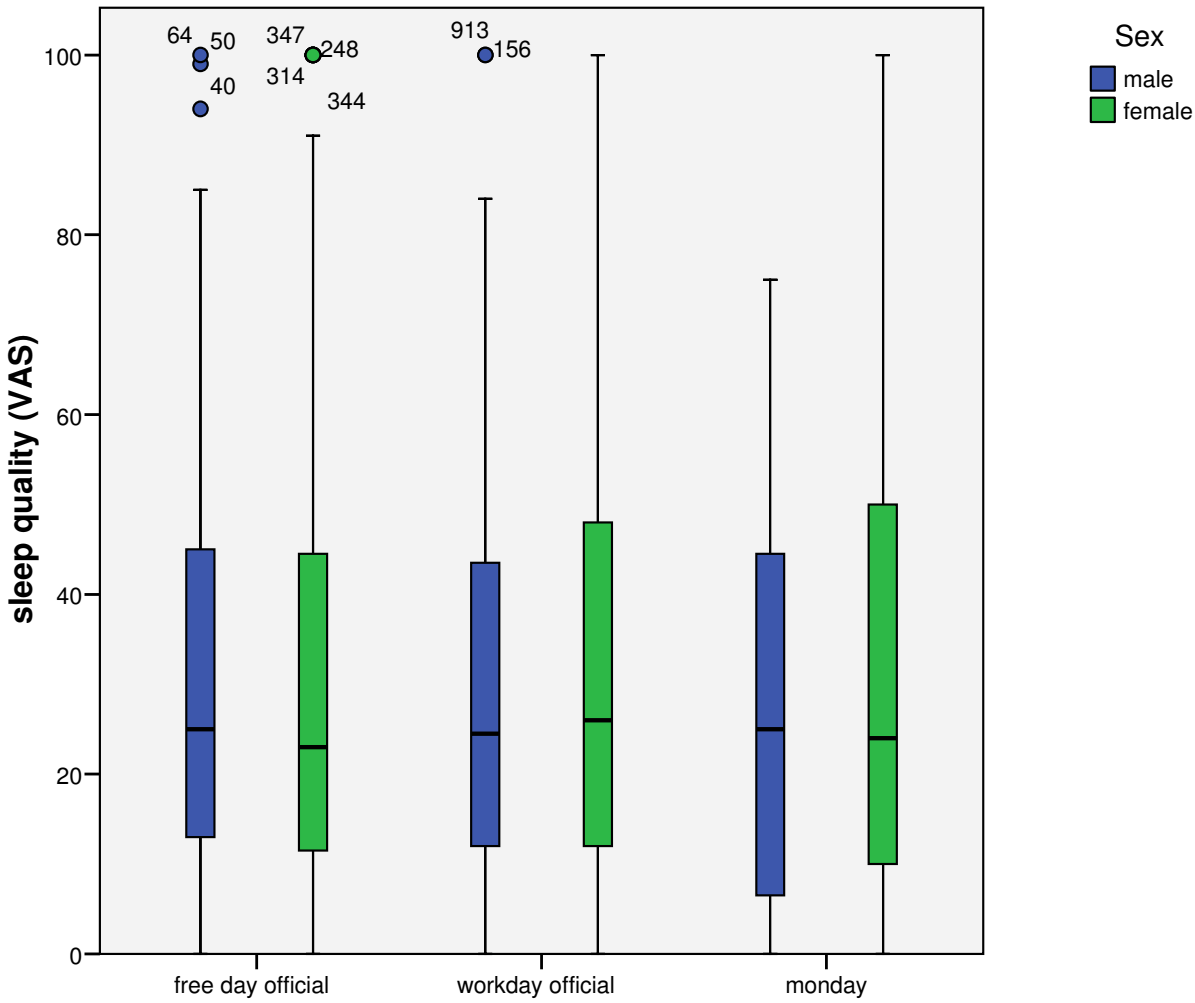

Fig. 3.3.2.: Sleep quality for male and female subjects in the nights prior to calendar free days, work days and for the nights from Sunday to Monday. Boxes are comprised of the first quartile (bottom of the box; middle value between the smallest number and the median) and third quartile (top of the box; middle value between the highest number and the median). Horizontal bars show the second quartile (the median). The ranges are represented as vertical lines. Outliers are circles with individual identities. Shown here are the results from all observed nights.

The data in Figure 3.3.2. demonstrates a slightly narrower range in the sleep quality of male subjects on the nights from Sunday to Monday. This indicates better sleep quality on that nights. Female subjects showed a wider range than male subjects, with no differences between the calendar free days, work days or the nights between Sunday and Monday.

The Kruskal Wallis test showed that the differences between sleep quality on weekends and sleep quality on weekdays were not significant for the male subjects ($p=0.703$) and female subjects ($p=0.560$).

3.4. Time in Bed on Free Days versus Work Days

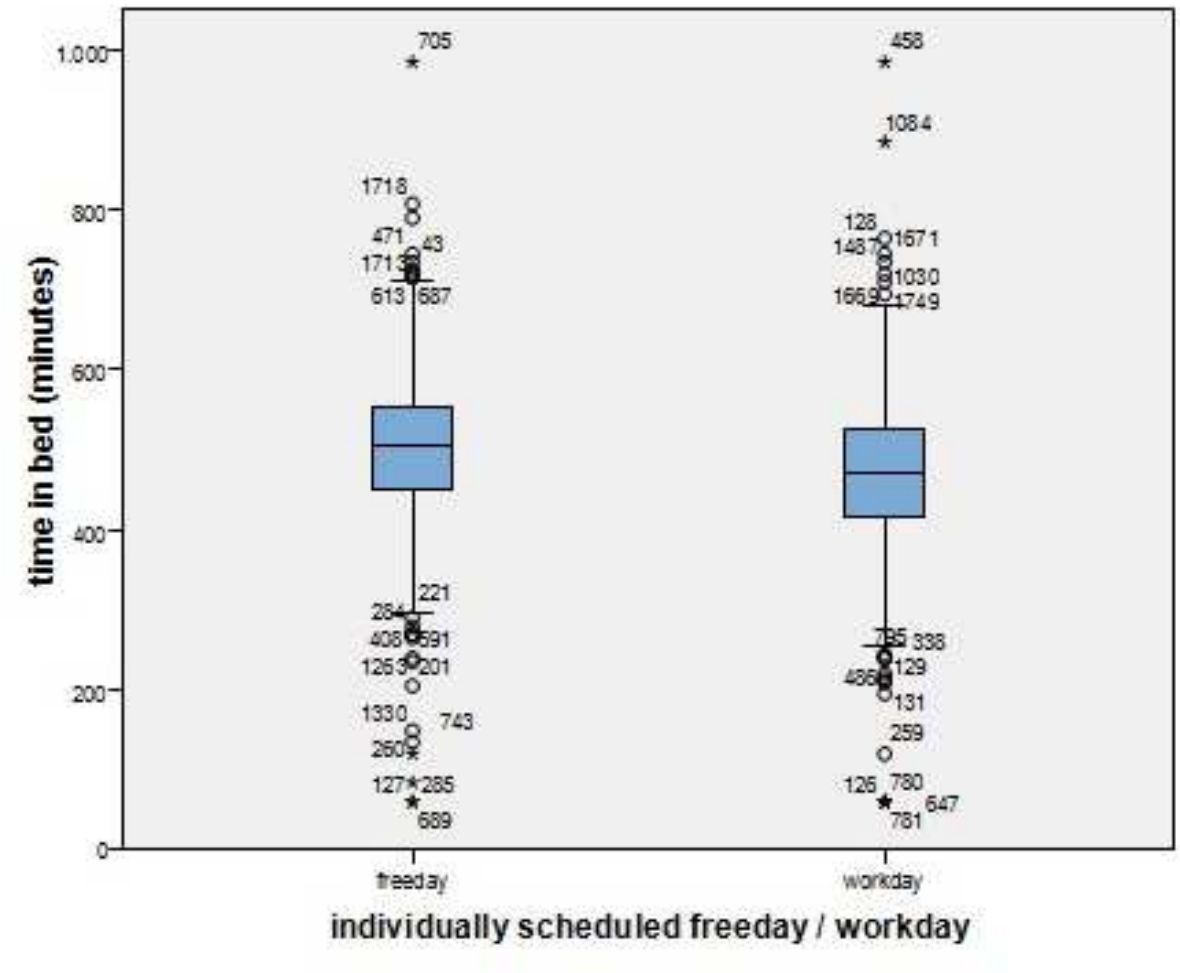

Fig. 3.4.1.: The amount of time spent in bed (in minutes) for all subjects on individually scheduled free days and work days. Boxes are comprised of the first quartile (bottom of the box; middle value between the smallest number and the median) and third quartile (top of the box; middle value between the highest number and the median). Horizontal bars show the second quartile (the median). The ranges are represented as vertical lines. Outliers are circles with individual identities. Shown here are the results from all observed nights.

In Figure 3.4.1. the amount of time spent in bed has been plotted. The subjects tended to sleep longer on individually scheduled free days. This difference was statistically significant (p=0.000).

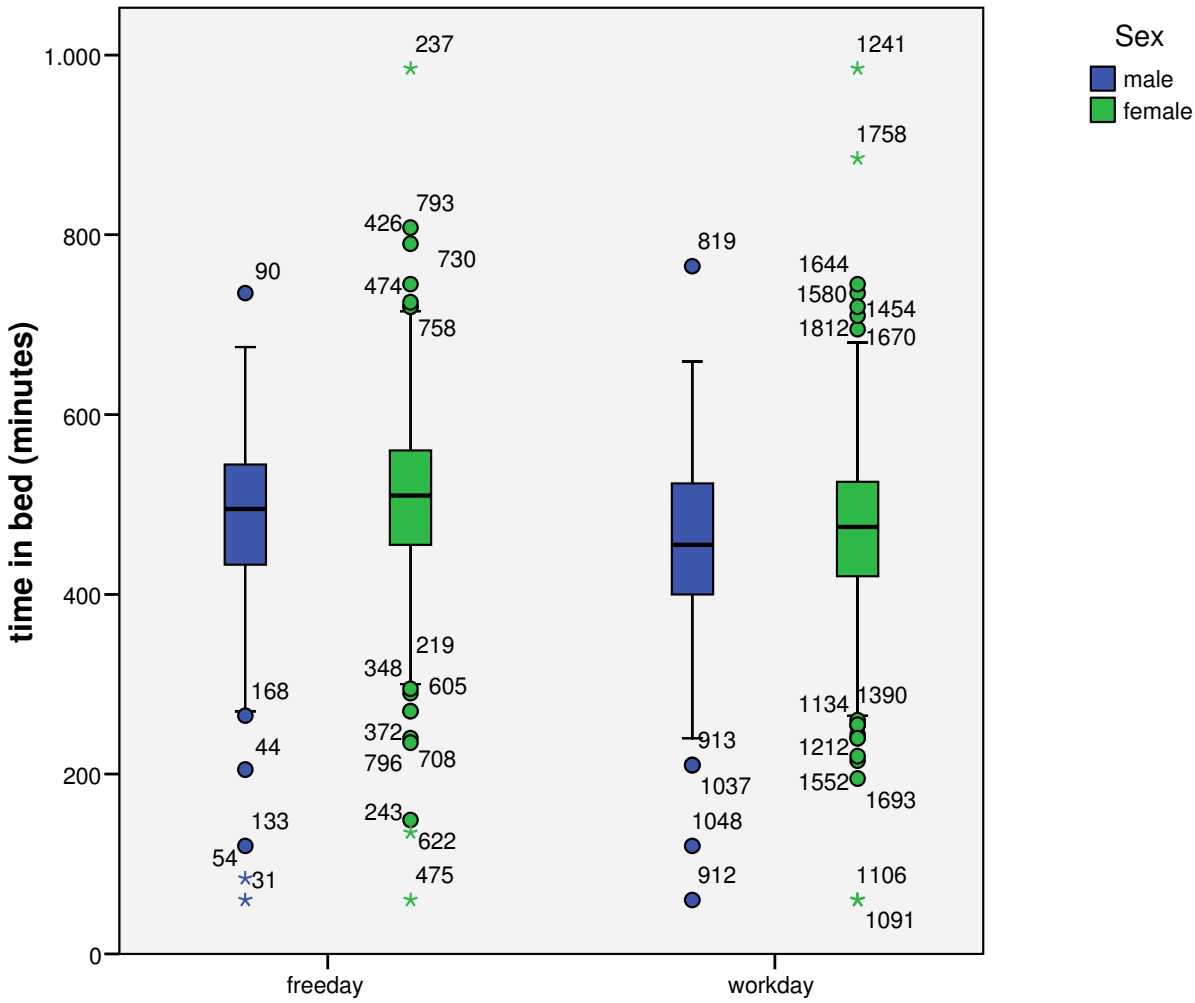

Fig. 3.4.2.: The amount of time spent in bed (in minutes) for male and female subjects on individually scheduled free days and work days. Boxes are comprised of the first quartile (bottom of the box; middle value between the smallest number and the median) and third quartile (top of the box; middle value between the highest number and the median). Horizontal bars show the second quartile (the median). The ranges are represented as vertical lines. Outliers are circles with individual identities. Shown here are the results from all observed nights.

In Figure 3.4.2. the time spent in bed has been plotted. Male subjects showed an overall narrower range. In addition, the extreme outliers over the normal sleeping time were exclusively women. Both male and female subjects seem to have slept longer on individually scheduled free days. The majority of women tended to sleep longer, on both free days and work days.

Table 3.4.1.: Descriptive statistics for individually scheduled free days and work days for the amount of time spent in bed (in minutes) in male and female subjects. N refers to the number of nights that were included in the analysis. Significant differences were tested by the Mann-Whitney U-test.

Time in Bed		Work days	Free days	Significance of difference FD / WD
Male subjects	n	259	187	0.001
	MW ± SD	452,58 ± 91,61	478,98 ± 104,16	
Female subjects	n	755	598	0.000
	MW ± SD	467,32 ± 89,44	505,51 ± 93,09	

As can be seen in Table 3.4.1. the Mann-Whitney U-test showed that the differences between the time in bed on free days and work days were significant for both sexes (male subjects: p=0.001; female subjects p=0.000).

3.5. Time In Bed on Weekdays versus Weekends

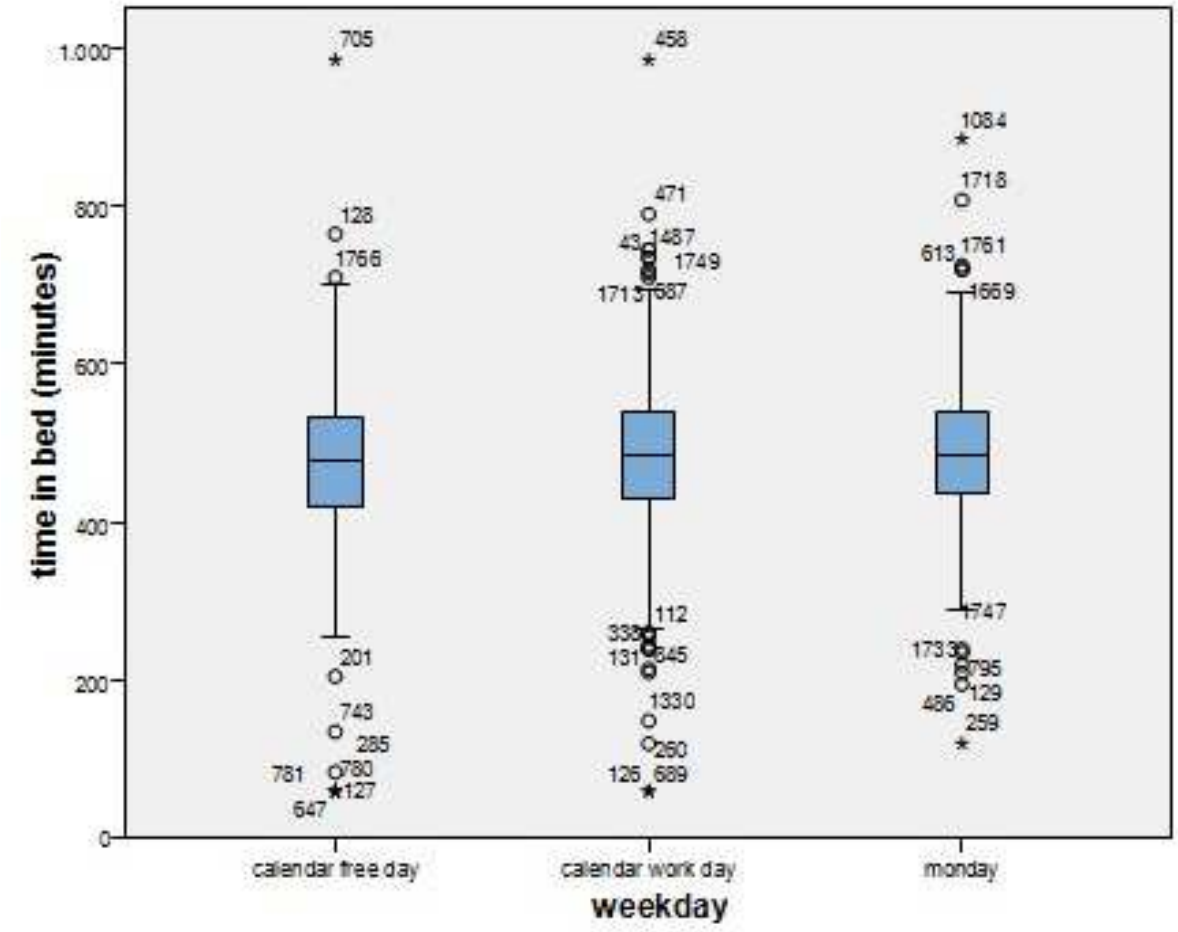

Fig. 3.5.1.: The amount and variation of time in bed (in minutes) in all subjects on calendar free days and work days and the nights from Sunday to Monday. Boxes are comprised of the first quartile (bottom of the box; middle value between the smallest number and the median) and third quartile (top of the box; middle value between the highest number and the median). Horizontal bars show the second quartile (the median). The ranges are represented as vertical lines. Outliers are circles with individual identities. Shown here are the results from all observed nights.

From the data presented in Figure 3.5.1., it is evident that there were no differences between the amount of time spent in bed on calendar free days and work days or on the nights from Sunday to Monday. The differences between the nights were not statistically significant (p=0.080).

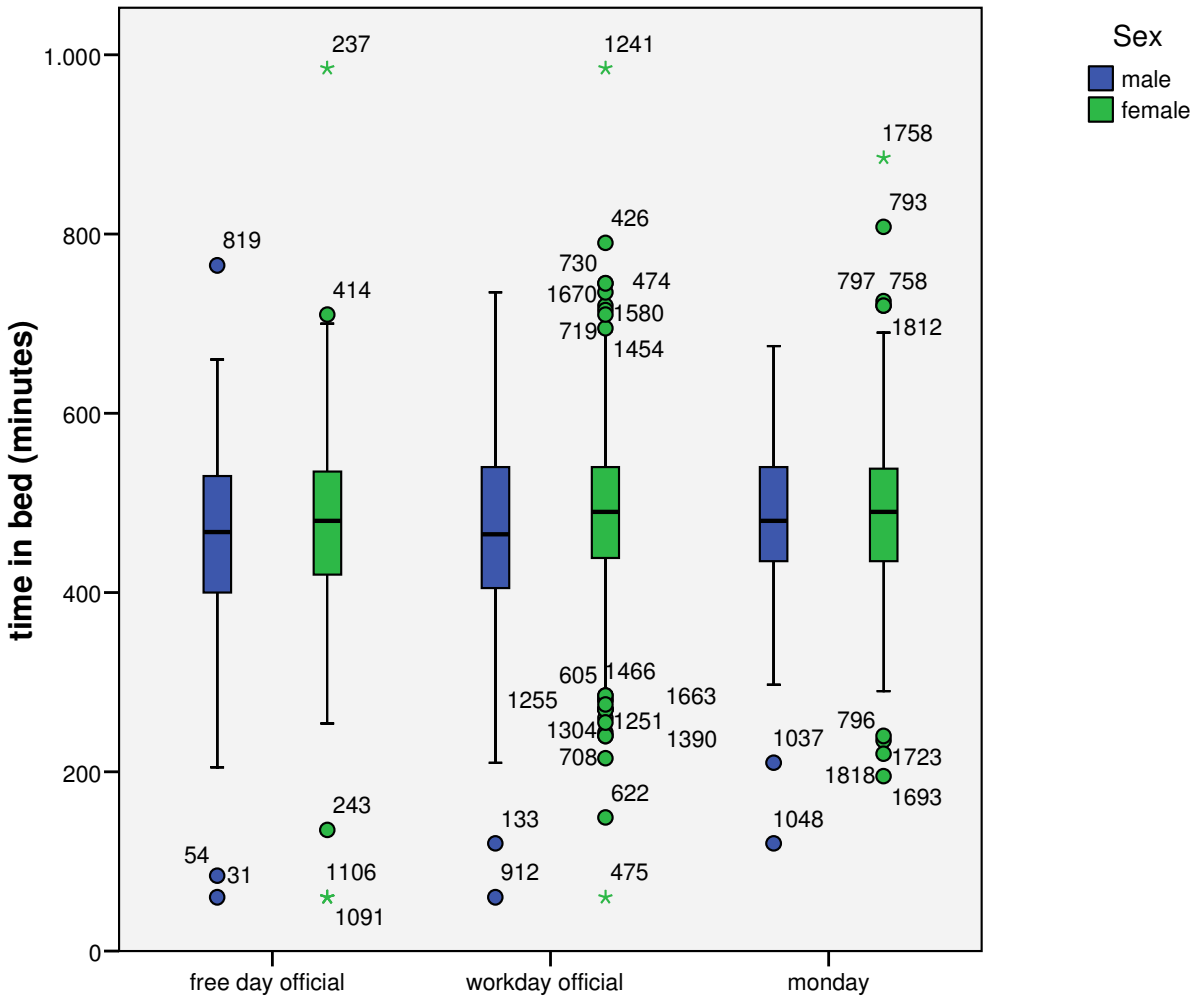

Fig. 3.5.2.: The median and the variation of the time in bed (in minutes) in male and female subjects on calendar free days and work days and on the nights from Sunday to Monday. Boxes are comprised of the first quartile (bottom of the box; middle value between the smallest number and the median) and third quartile (top of the box; middle value between the highest number and the median). Horizontal bars show the second quartile (the median). The ranges are represented as vertical lines. Outliers are circles with individual identities. Shown here are the results from all observed nights.

As can be seen in Figure 3.5.2., there were only small differences between the "time in bed" (TIB) on calendar free days and work days or on the nights from Sunday to Monday. There was also a large amount of scattering on calendar work days as well as a difference in range between male and female subjects.
In general, the female subjects showed a higher variability in their time spent in bed than male subjects. The Kruskal-Wallis test showed that the difference in TIB between weekends and weekdays were not significant for men (p=0.397) and women (p=0.064).

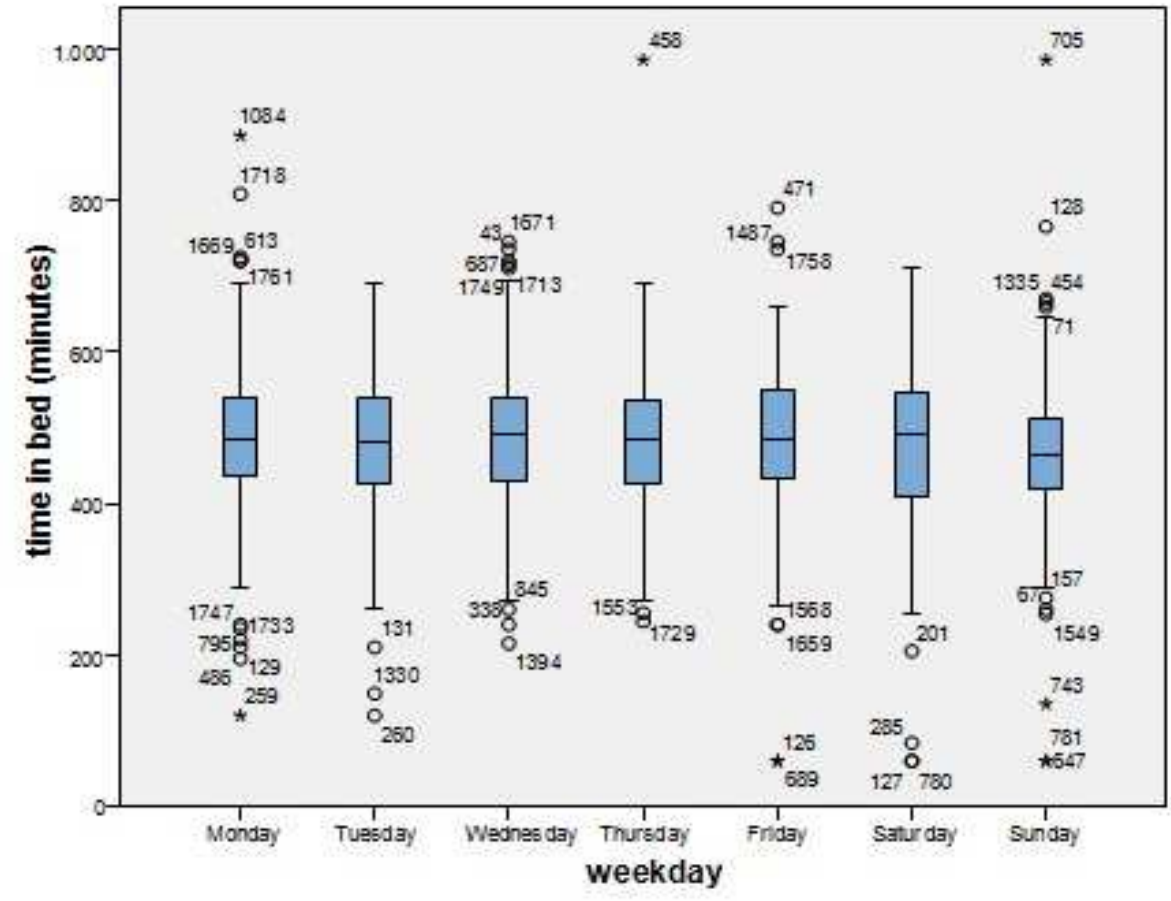

Fig. 3.5.3.: The graph shows the amount and variation of the time spent in bed (in minutes) in all subjects for all weekdays (the night from Sunday to Monday, the night from Monday to Tuesday, the night from Tuesday to Wednesday, the night from Wednesday to Thursday, the night from Thursday to Friday, the night from Friday to Saturday and the night from Saturday to Sunday). Boxes are comprised of the first quartile (bottom of the box; middle value between the smallest number and the median) and third quartile (top of the box; middle value between the highest number and the median). Horizontal bars show the second quartile (the median). The ranges are represented as vertical lines. Outliers are circles with individual identities. Shown here are the results from all observed nights.

In Figure 3.5.3. the medians of the time spent in bed for each weeknight have been plotted. Even though the differences appear to be minimal they turned out to be statistically significant (p=0.042).

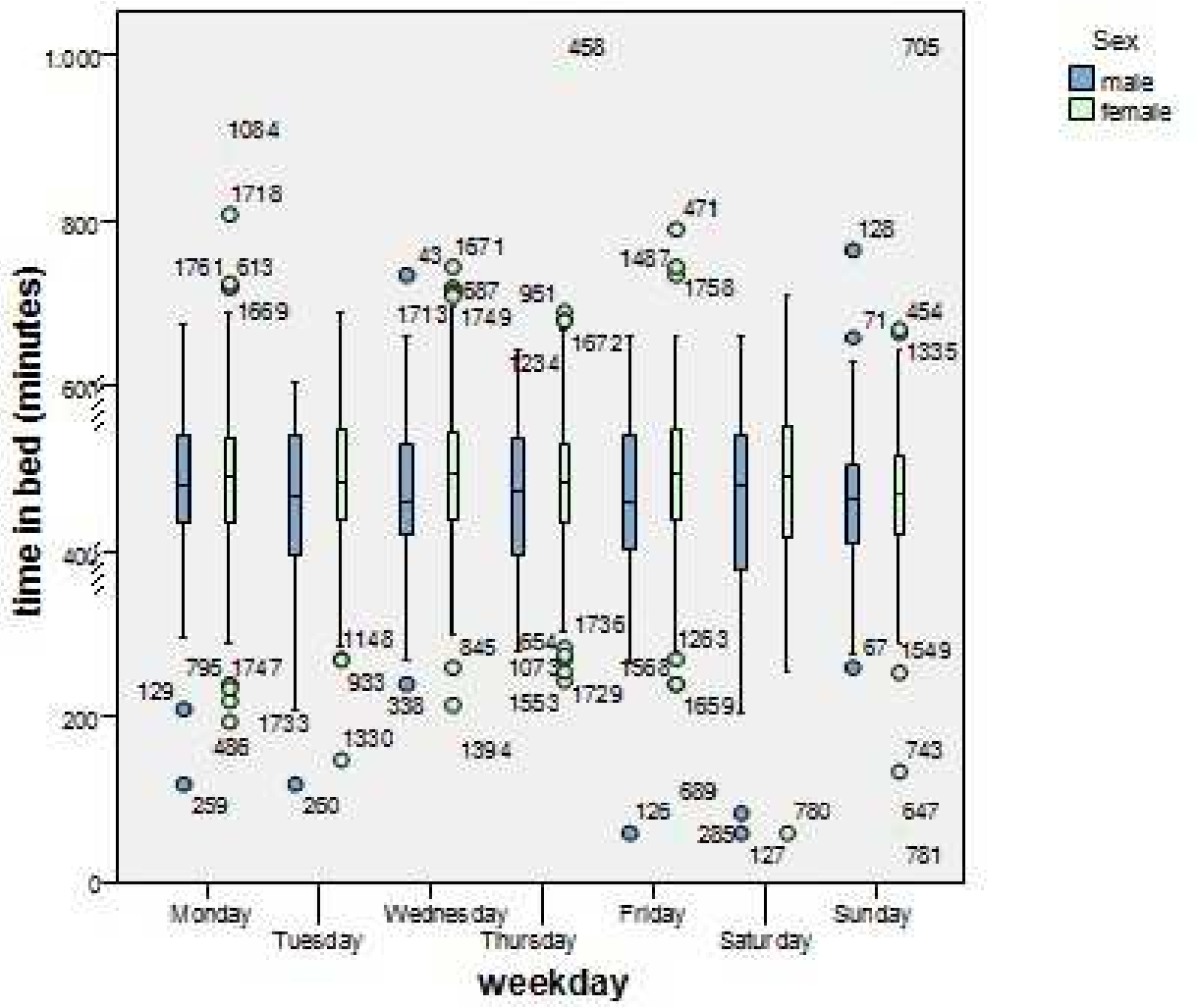

Fig. 3.5.4.: The amount and variation of time spent in bed (in minutes) in male and female subjects on all weekdays (the night from Sunday to Monday, the night from Monday to Tuesday, the night from Tuesday to Wednesday, the night from Wednesday to Thursday, the night from Thursday to Friday, the night from Friday to Saturday and the night from Saturday to Sunday). Boxes are comprised of the first quartile (bottom of the box; middle value between the smallest number and the median) and third quartile (top of the box; middle value between the highest number and the median). Horizontal bars show the second quartile (the median). The ranges are represented as vertical lines. Outliers are circles with individual identities. Shown here are the results from all observed nights.

To further illustrate the differences in the nights during one week as shown before in Figure 3.5.3., the medians for the TIB were calculated separately for male and female subjects (Figure 3.5.4.).

The women showed a wider range of variation than the men, especially in the direction of longer than average sleep. The female subjects slept also longer than the

male subjects. The male subjects showed the smallest range on Sundays and Mondays and slept longest on Saturdays. The female subjects showed a slightly smaller range in the TIB on Sundays and slept longest on Saturdays.
The differences in TIB during the week were not significant for the male subjects (p=0.831), whereas there was significance for the female subjects (p=0.049).

Table 3.5.1.: Descriptive statistics for the weeknights (the night from Sunday to Monday (M), the night from Monday to Tuesday (T), the night from Tuesday to Wednesday (W), the night from Wednesday to Thursday (Th), the night from Thursday to Friday (F), the night from Friday to Saturday (Sa) and the night from Saturday to Sunday (S)) for the amount of time spent in bed (in minutes) in male (M) and female (F) subjects.
N refers to the number of nights that were included in the analysis. Significant differences (Sign.) were tested with the Mann-Whitney U-test.

		M	T	W	Th	F	Sa	S	Sign.
TIB M	n	59	60	64	68	67	65	65	0.831
	MW ± SD	475,44 ± 95,87	455,13 ± 101,31	472,94 ± 84,75	465,09 ± 86,44	457,84 ± 104,65	460,72 ± 120,51	460,06 ± 87,98	
TIB F	n	184	189	194	198	198	200	197	0.049
	MW ± SD	487,77 ± 94,57	489,47 ± 86,58	489,72 ± 84,85	487,37 ± 87,57	488,25 ± 96,23	483,44 ± 101,79	464,30 ± 95,86	

3.6. Sleep Efficiency (Objective and Subjective) on Free Days versus Work Days

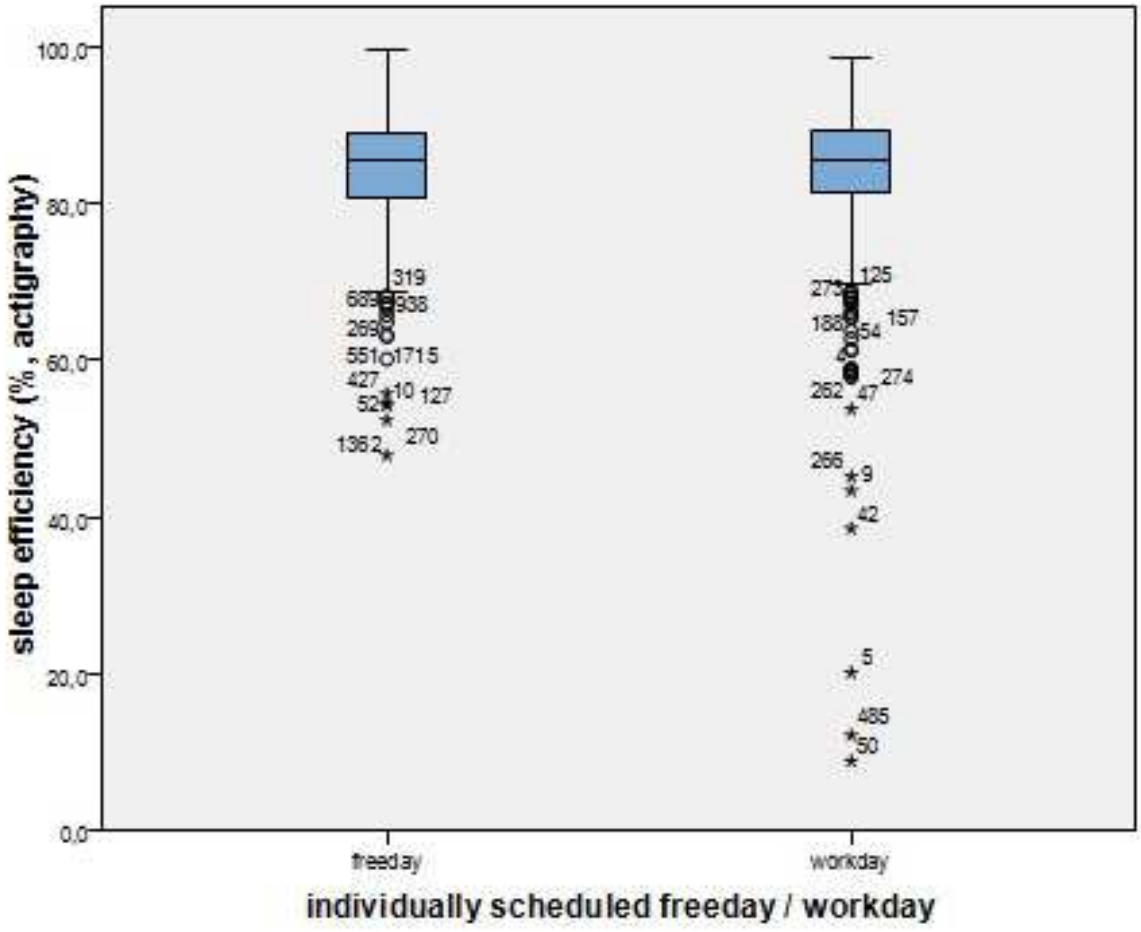

Fig. 3.6.1.: The sleep efficiency, as calculated by actigraphs for all subjects on individually scheduled free days and work days. Boxes are comprised of the first quartile (bottom of the box; middle value between the smallest number and the median) and third quartile (top of the box; middle value between the highest number and the median). Horizontal bars show the second quartile (the median). The ranges are represented as vertical lines. Outliers are circles with individual identities. Shown here are the results from all observed nights.

The actigraphically calculated sleep efficiency (SEa) has been plotted in Figure 3.6.1. Although the median did not demonstrate differences between free days and work days there was a much wider range of variation in the SEa on work days. However, the statistical analysis showed that the difference was not significant (p=0.519).

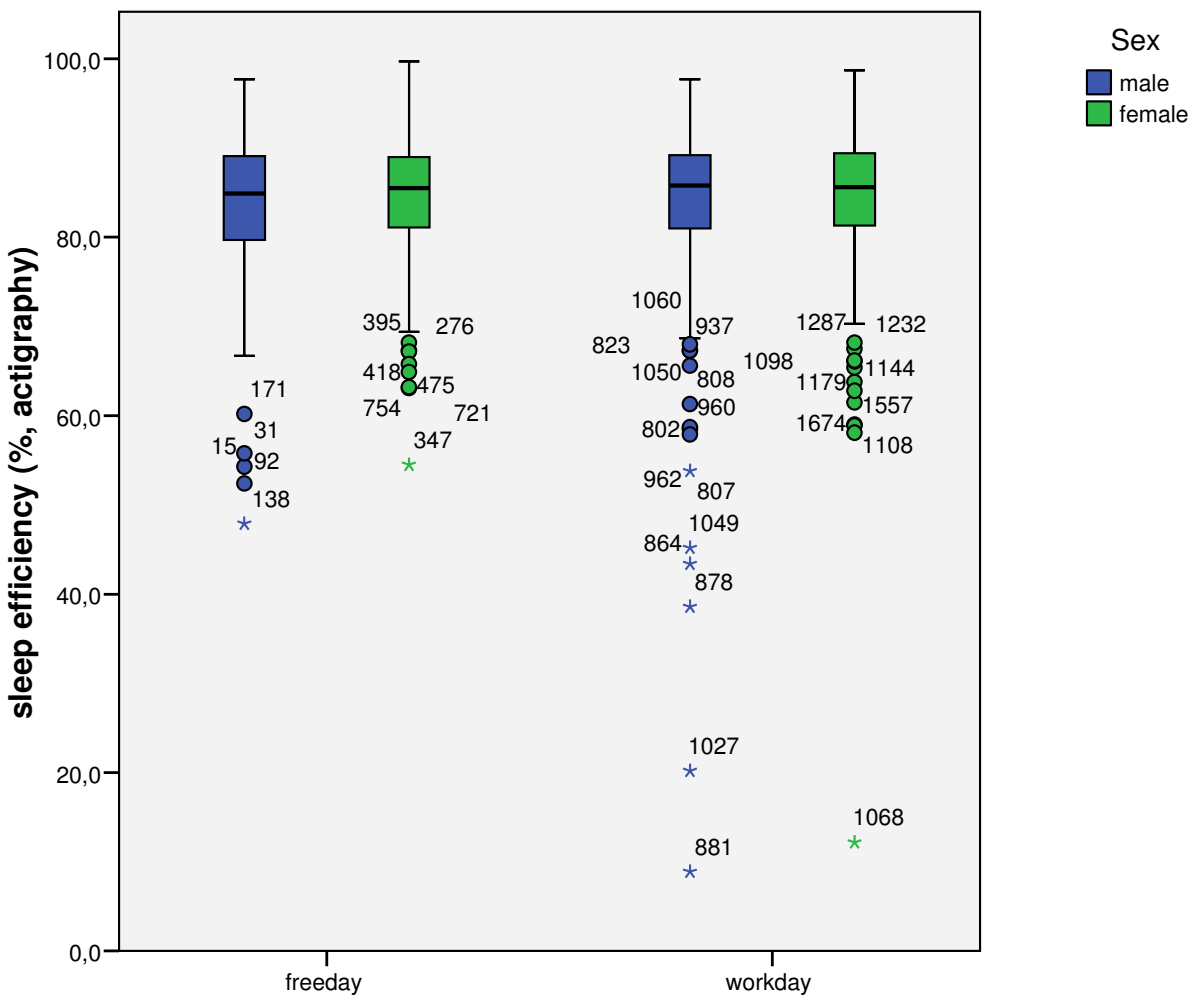

Fig. 3.6.2.: The sleep efficiency, as calculated by actigraphs, for male and female subjects on individually scheduled free days and work days. Boxes are comprised of the first quartile (bottom of the box; middle value between the smallest number and the median) and third quartile (top of the box; middle value between the highest number and the median). Horizontal bars show the second quartile (the median). The ranges are represented as vertical lines. Outliers are circles with individual identities. Shown here are the results from all observed nights.

In Figure 3.6.2., the actigraphically calculated sleep efficiency (SEa) has been plotted for both sexes. In the nights prior to work days the subjects showed a higher variability in their SEa than in the nights prior to free days. Moreover, males showed a wider range than females. The differences between SEa on free days and work days were not significant (Mann-Whitney U-test) for men (p= 0.589) and women (p= 0.670).

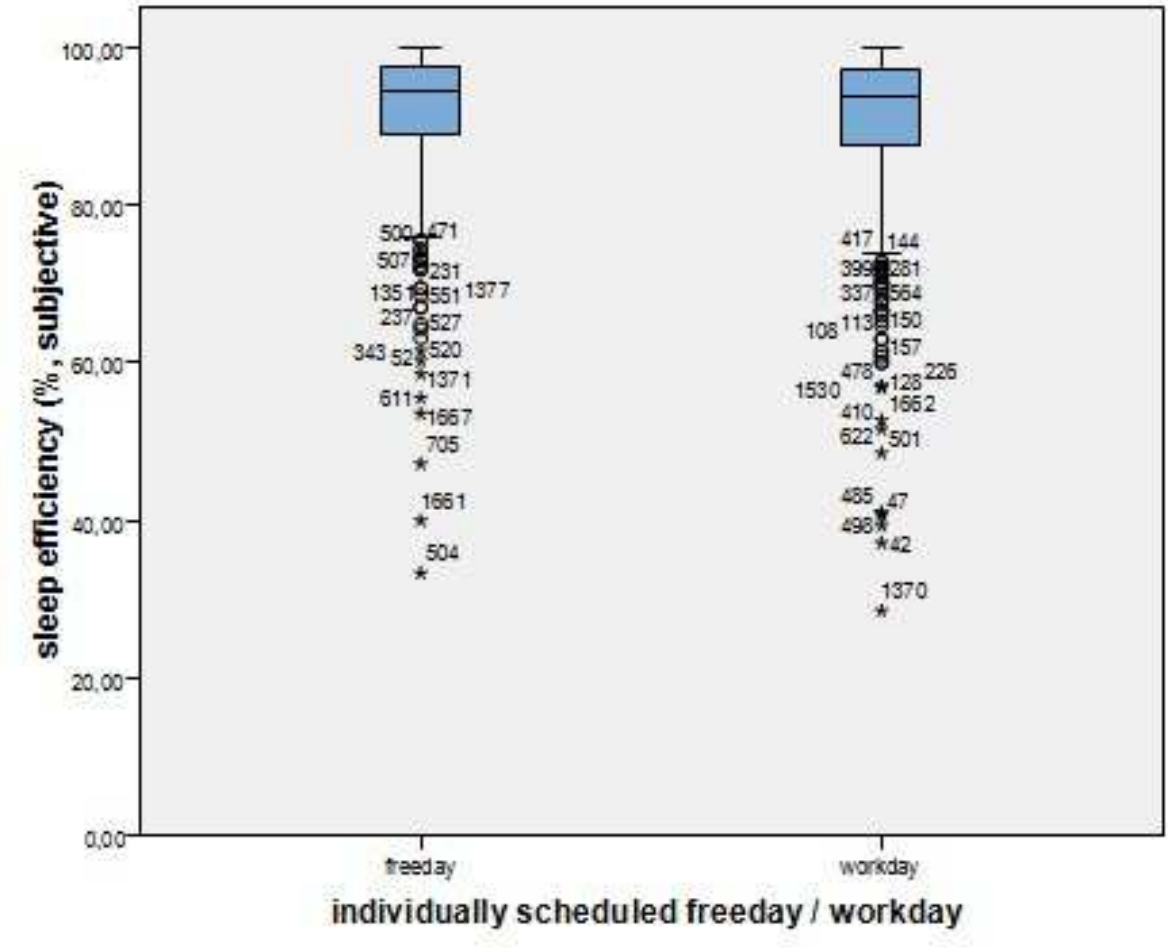

Fig. 3.6.3.: The subjective sleep efficiency (SEs) for all participants on individually scheduled free days and work days. Boxes are comprised of the first quartile (bottom of the box; middle value between the smallest number and the median) and third quartile (top of the box; middle value between the highest number and the median). Horizontal bars show the second quartile (the median). The ranges are represented as vertical lines. Outliers are circles with individual identities. Shown here are the results from all observed nights.

Figure 3.6.3. illustrates the subjective sleep efficiency (SEs) for all participants on nights before free days and work days. The differences in SEs in the nights before free and work days were significant (Mann-Whitney U-test: p=0.009).

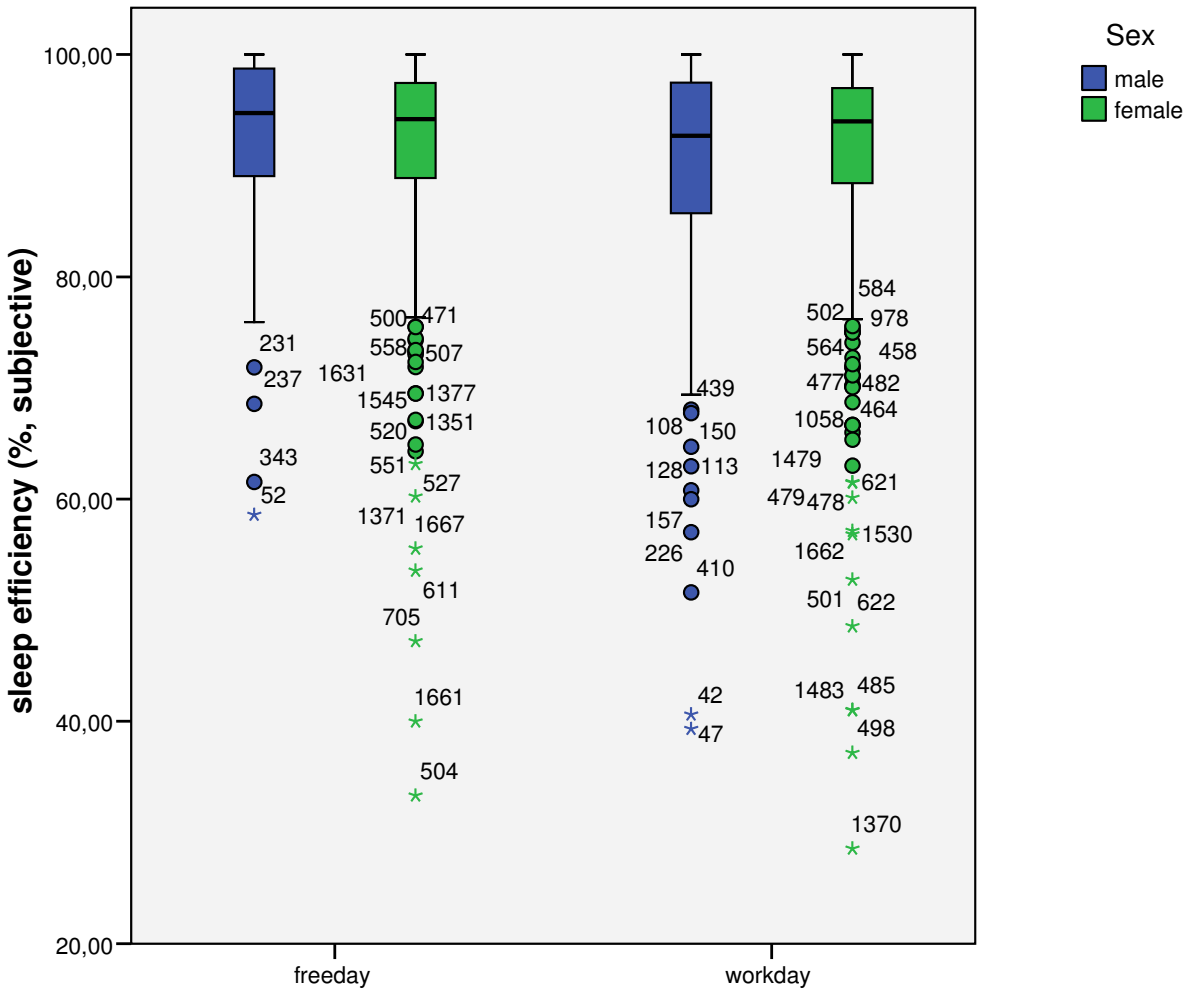

Fig. 3.6.4.: The subjective sleep efficiency (SEs) for males and females on individually scheduled free days and work days. Boxes are comprised of the first quartile (bottom of the box; middle value between the smallest number and the median) and third quartile (top of the box; middle value between the highest number and the median). Horizontal bars show the second quartile (the median). The ranges are represented as vertical lines. Outliers are circles with individual identities. Shown here are the results from all observed nights.

In Figure 3.6.4. the distribution of the subjective sleep efficiency (SEs) in nights before free days and work days have been presented separately for men and women. Women show more variability in their SEs than men.

Table 3.6.1.: Descriptive statistics for the subjective sleep efficiency (in percent) on nights before individually scheduled free days and work days for males and females. N refers to the number of nights that were included in the analysis. Significant differences were tested by the Mann-Whitney U-test.

Sleep Efficiency (subjective)		Work days	Free days	Significance of difference FD / WD
Male subjects	n	242	179	0.005
	MW ± SD	90,01 ± 10,11	92,63 ± 7,60	
Female subjects	n	705	565	0.170
	MW ± SD	91,35 ± 8,69	91,96 ± 8,09	

As shown in Table 3.6.1., the Mann-Whitney U-test showed that the differences in subjective sleep efficiency (SEs) on the nights prior to free days and work days were significant for the men (p=0.005) but not for the women (p=0.170).

3.7. Sleep Efficiency (Objective and Subjective) on Weekdays versus Weekends

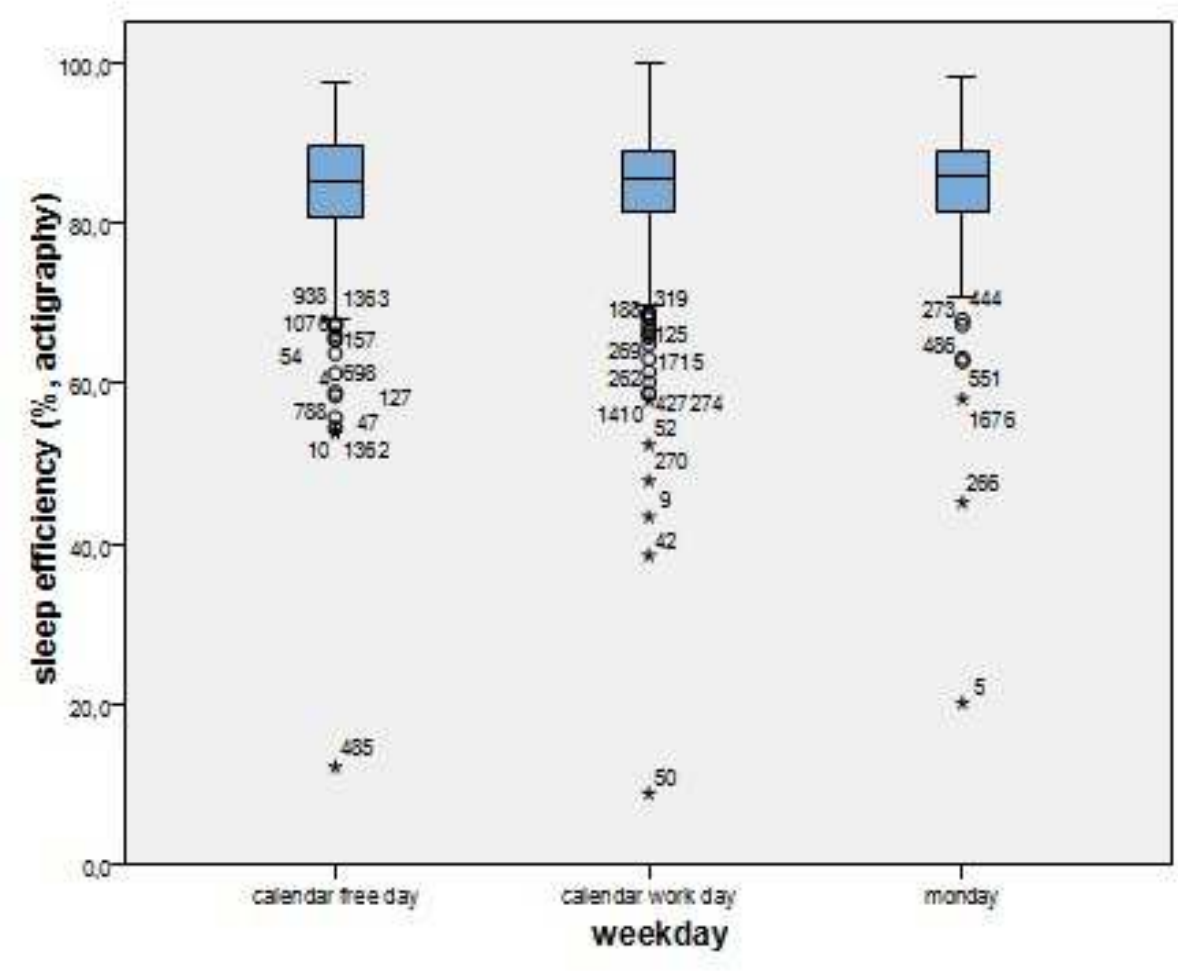

Fig. 3.7.1.: The actigraphically calculated sleep efficiency (SEa) for all subjects on calendar free days and work days and the nights from Sunday to Monday. Boxes are comprised of the first quartile (bottom of the box; middle value between the smallest number and the median) and third quartile (top of the box; middle value between the highest number and the median). Horizontal bars show the second quartile (the median). The ranges are represented as vertical lines. Outliers are circles with individual identities. Shown here are the results from all observed nights.

In Figure 3.7.1., the medians in SEa in the nights prior to calendar free days and work days and in the nights from Sunday to Monday have been presented.
The differences were tested and proved to be not statistically significant (p=0.931).

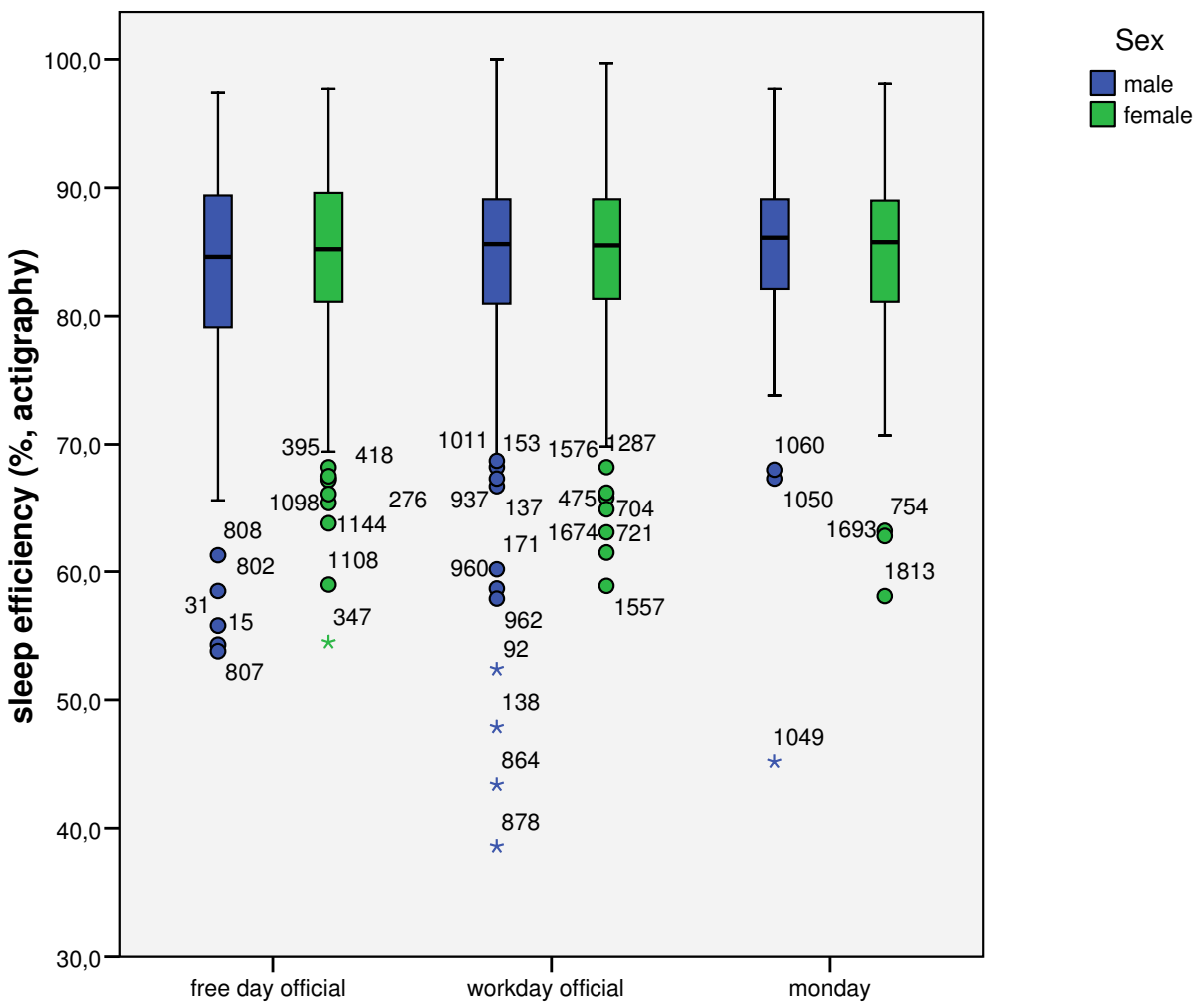

Fig. 3.7.2: The actigraphically calculated sleep efficiency (SEa) in males and females on calendar free days and work days and the nights from Sunday to Monday. Boxes are comprised of the first quartile (bottom of the box; middle value between the smallest number and the median) and third quartile (top of the box; middle value between the highest number and the median). Horizontal bars show the second quartile (the median). The ranges are represented as vertical lines. Outliers are circles with individual identities. Shown here are the results from all observed nights.

In Figure 3.7.2. it is evident that the actigraphically calculated sleep efficiency did not vary much in the nights prior to calendar free days and work days or in the nights from Sunday to Monday. Overall less variance appeared in the nights from Sundays to Monday. The differences between actigraphically calculated sleep efficiency (SEa) on weekend- and weekday-nights were not statistically significant for either males (p=0.670) or females (p=0.968).

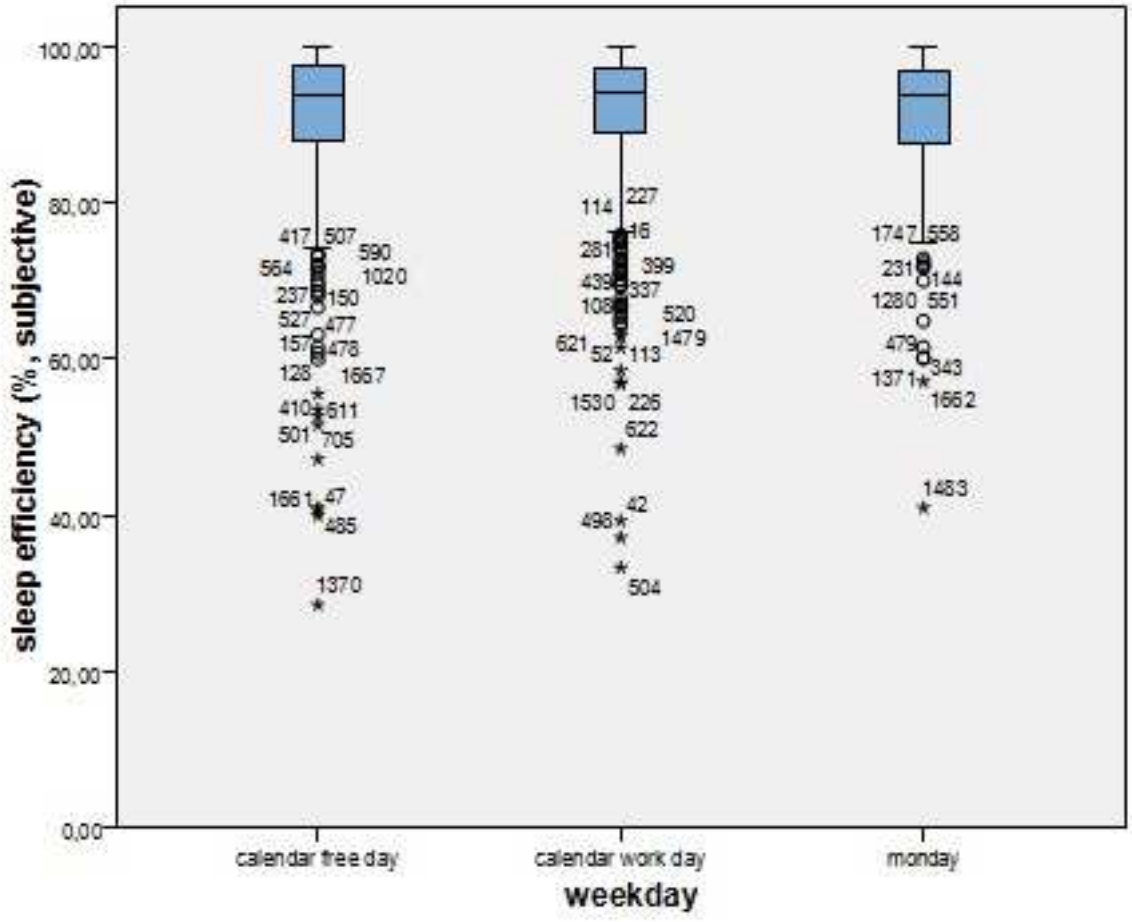

Fig. 3.7.3.: The subjective sleep efficiency in all subjects on calendar free days and work days and the nights from Sunday to Monday. Boxes are comprised of the first quartile (bottom of the box; middle value between the smallest number and the median) and third quartile (top of the box; middle value between the highest number and the median). Horizontal bars show the second quartile (the median). The ranges are represented as vertical lines. Outliers are circles with individual identities. Shown here are the results from all observed nights.

In Figure 3.7.3. it appears that there were slight differences in the range of subjective sleep efficiencies. The least amount of scatter was on the nights from Sunday to Monday. The results were not significant (p=0.702).

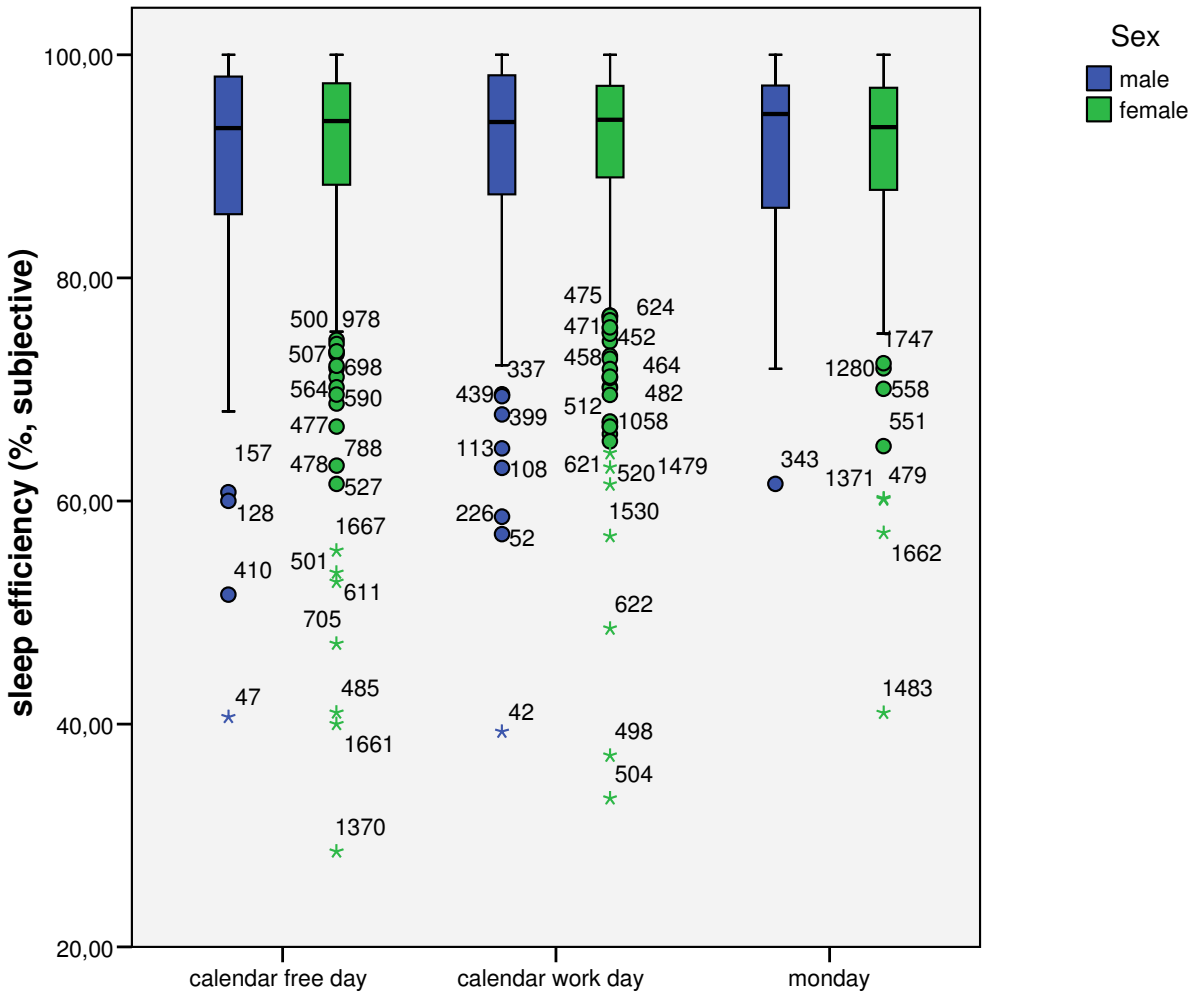

Fig. 3.7.4.: The subjective sleep efficiency in males and females on calendar free days and work days and the nights from Sunday to Monday. Boxes are comprised of the first quartile (bottom of the box; middle value between the smallest number and the median) and third quartile (top of the box; middle value between the highest number and the median). Horizontal bars show the second quartile (the median). The ranges are represented as vertical lines. Outliers are circles with individual identities. Shown here are the results from all observed nights.

Females showed a higher variability in subjective sleep efficiency (SEs) during the nights prior to calendar free days and work days (Figure 3.7.4.). The differences in SEs between the nights on weekends and during the week were, however, not significant (Kruskal Wallis test); either for men (p=0.866) or women (p=0.674).

4. Discussion

The first key issue that was evaluated was whether or not there would be a difference in sleep quality between the nights prior to free days and work days. Concerning individually scheduled free days and work days a difference could be affirmed for both women and men. In general, females reported a better sleep quality than males but the differences were not significant.
Concerning the difference in sleep quality between weekends and weekdays no significant differences could be found.

The second key issue that was evaluated was whether or not there would be a difference in the amount of time spent in bed between free days and work days. Concerning individually scheduled free days and work days a highly significant difference could be affirmed.
Concerning the difference in the amount of time spent in bed between weekends and weekdays the difference was only partly disproved. No significant differences were found in the comparison of days as a block (the nights from Sunday to Monday versus the rest of the calendar work days versus the calendar free days). While the findings proved highly insignificant for the male subjects, the insignificance for the female subjects was not very high. This slight insignificance of time spent in bed for the female subjects prompted a more detailed comparison of the weeknights not as blocks but as individual nights. The time spent in bed for each individual weeknight showed significant differences. Whereas the results of the men proved highly insignificant, the women showed a significant difference in the amount of time spent in bed during the whole week as well as in the time spent in bed on weekends compared to the nights on weekdays. Further research is necessary to determine whether this gender difference really exists or was simply caused by the fact that there were less male probands in the analysed dataset.
Concerning both the results for individually scheduled days and calendar days, the women generally slept longer than the men, especially in the nights before free days. This gender effect in sleep time together with the gender-specific higher amount of time spent in bed on weekends was previously reported by Tsai and Li (2004).

The third key issue was whether or not there would be a difference in both the actigraphically based sleep efficiency (SEa) and the subjective sleep efficiency (SEs) in nights prior to free days and work days.
For SEa no differences could be found, but for SEs the findings were not as clear. As with SEa the differences for the SEs between weekends and weekdays were not significant. On the other hand, the differences for the SEs between individually scheduled free days and work days only proved insignificant for the female participants. The male participants showed significant differences concerning the SEs between individually scheduled free days and work days.

Calendar work days and free days had no impact on sleep quality and both actigraphically based and subjective sleep efficiency in all participants.
Therefore, one might speculate that sleep is far more influenced by individual schedules than by social schedules (such as weekends). Nevertheless, for females the time spent in bed (TIB) varied significantly on weekends. While TIB did not differ in the nights of the week from Sunday to Saturday, females spent less time in bed in the nights from Saturday to Sunday (464 minutes versus 485.5 minutes).
While it could be argued that this demonstrated the opposite of a sleep catch-up strategy and therefore further reinforces the conclusion that people with individual schedules do not show any kind of attachment to calendar work days and free days, a difference of only 19 to 26 minutes does not prove much. Additionally, since the difference was found on the nights from Saturday to Sunday, one could argue that a lot of the students probably engaged in typical Saturday evening events that by their very nature probably contained staying up later than usual.

Weekend-effects were not present in this study but this does not mean that none existed for the individually scheduled free days. In general, all tested subjects slept longer during nights of individually scheduled free days. The mean score for all subjects was 464 minutes on the nights prior to work days versus 499 minutes on the nights prior to free days (difference of 35 minutes). Males slept on average 453 minutes on work days versus 479 minutes on free days (difference of 26 minutes). Females slept on average 467 minutes on work days and 506 minutes on free days (difference of 39 minutes). Even though these numbers prove that everyone slept longer on free days, this does not necessarily count as a weekend-effect.

A weekend-effect not only consists of a longer sleep-period on free days but of a permanent sleep deprivation on work days as well (Kerbl et al., 2006; Wittmann et al., 2006). Iglowstein et al. (2003) defined the normal sleep duration for adolescents of about 16 years as a range between 438 and 534 minutes. Since adults need a little less sleep, the normal sleep duration for adults is defined as a range between 420 and 480 minutes (Morgenthaler, Mayoclinic, 2013; Zee, Medscape, 2005).
None of the measured amounts of time spent in bed were lower than this range or in fact even close to the lower spectrum of it. For this reason, it can be said that no social jetlag existed for the test subjects, even though the amount of time spent in bed exceeded the normal range on free days in case of the female probands.

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6. Addendum

6.1. Abstract

The so-called weekend effect with sleep deprivation over the week and sleep catch-up over the weekend has been observed in children, teenagers and even adults. The present study wanted to observe differences in sleep parameters between work days and free days for a group of students who were able to schedule their sleep patterns more individually than usual for most adults. Apart from showing differences between free days and work days, it was to be observed if calendar weekdays affected people with individual schedules at all. Furthermore, this study hoped to observe eventual gender differences as well as determining whether the observed students with individual schedules were objected to the weekend-effect.
The observed parameters were subjective sleep quality, amount of time spent in bed and both objective and subjective sleep efficiency.

Even though there were differences to be found for all parameters, only a few were significant, namely the amount of time spent in bed for both genders and the subjective sleep efficiency of the male subjects on individually scheduled free days and work days; as well as partially the amount of time spent in bed of the female subjects on calendar free days and work days. The main difference between genders was the fact that women slept longer overall. Despite significant differences between free days and work days, no weekend-effect could be detected.

Der so genannte Wochenend-Effekt mit akkumuliertem Schlafdefizit im Laufe der Woche und Nachholbedarf von Schlaf am Wochenende wurde bereits bei Kindern, Jugendlichen und sogar Erwachsenen dokumentiert. Mit der vorliegenden Studie sollten Unterschiede in Schlaf-Parametern zwischen Arbeitstagen und freien Tagen untersucht werden. Die Untersuchung betraf eine Gruppe von Studenten, die sich ihre Schlafgewohnheiten und Arbeitstage beziehungsweise freie Tage individueller einteilen konnten als dies für die meisten Erwachsenen üblich ist. Zusätzlich zum eventuellen Nachweis von Unterschieden zwischen Arbeitstagen und freien Tagen wurde außerdem noch untersucht ob Kalender-Tage auch Personen mit einer individuellen Arbeitseinteilung beeinflussen. Des Weiteren wurde mit dieser Studie versucht eventuelle Geschlechtsunterschiede zu untersuchen. Auch sollte festgestellt werden, ob der Wochenend-Effekt auch bei Studenten mit individueller Arbeitseinteilung auftritt. Die untersuchten Parameter waren die subjektive Schlafqualität, die im Bett verbrachte Zeit und sowohl die objektive als auch die subjektive Schlafeffizienz. Zwar konnten bei allen Parametern Unterschiede festgestellt werden, jedoch waren nur ein paar davon signifikant. Die signifikanten Ergebnisse betrafen die im Bett verbrachte Zeit für sowohl Männer als auch Frauen und die subjektive Schlafeffizienz der Männer beim Vergleich der individuellen Arbeitstage und freien Tage. Im Vergleich zwischen Kalendertagen zeigte sich nur die im Bett verbrachte Zeit der Fauen als mehr oder weniger signifikant. Der Hauptunterschied zwischen den Geschlechtern war die Tatsache, dass Frauen generell länger schliefen als Männer. Trotz der signifikanten Unterschiede zwischen Arbeitstagen und freien Tagen konnte kein Wochenend-Effekt festgestellt werden.

6.2. Acknowledgment

I want to offer my thanks to the people who supported me and kept me going.
Foremost I want to thank my family, especially my mother Mag.ª Christine Cézanne-Thauss, but also my father Carl Cézanne and my brother Simon Ourada, for their constant encouragement. I am also very grateful for the help of my cousin and good friend Mag.ª Karoline Mühlbacher for offering advise on how to write a diploma thesis and for proofreading.
Essential for the finishing of this thesis was also the help of Dr. Irene Zweimüller, without which it would have taken me a very long time to figure out how to use statistical analysis programs and how to produce good graphs.
A very important factor for keeping me sane throughout this process were the phone conversations and sporadic meetings with my two close friends Martina Steinhofer and Sabrina Blaim.
And last but not least I want to thank Dr. John Dittami from the Department of Anthropology at the University of Vienna - the professor who made this work possible - and my supervisor Dr. Gerhard Klösch, somnologist at the Department of Neurology at the Medical University of Vienna.

6.3. Curriculum vitae

I, Rita Cézanne, was born on the first of October 1987 as daughter to Mag.ª Christine Cézanne-Thauss and Carl Cézanne in Korneuburg, Lower Austria.

Educational Background:

1993-1997	Elementary School
1997-2005	Secondary High School
June 2005	Acquisition of High School Diploma
Winter Term 2005 - Winter Term 2012	Study of Biology
Winter Term 2012 - Winter Term 2013	Study of Zoology

Work Experience:

2001-2005	Supervision of Children aged 6 Months - 7 Years
Summer 2003	Practical at Bird Ringing Station Grünau
2006-2008	Honorary Work for VierPfoten
2008-2012	12-15 Hours a Week as a Waitress
March 2012	Practical at Konrad Lorenz Research Centre Grünau
Summer 2012	Practical in History of Molluscs at the Natural History Museum Vienna
November 2012	Practical in DNA-Sequence Analysis and Molecular Phylogeny at the University of Vienna
December 2012	Practical in Applicaton of Polymerase Chain Reaction at the Danube Hospital (Donauspital) Vienna
March-June 2013	Practical in Experimental Evolutionary Biology at the University of Vienna