Time Use for Sleeping in Relation to Waking Activities

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Abstract

Study Objectives: Evaluate the relationships between sleep time and 16 categories of waking activities from the American Time Use Survey (ATUS) database to determine which activities have a reciprocal relationship to sleep time, and which do not.

Design: Cross sectional survey data.

Setting: NA

Participants: A nationally representative U.S. sample of people 15 years and older, from the 2003 American Time Use Survey. N = 20720.

Interventions: NA

Measurements: A 20-minute telephone interview in which participants were asked about the activities they engaged in going back 24 hours. Responses were codified using the 3-tiered ATUS activity classification system. The survey was sponsored by the Bureau of Labor Statistics and was conducted by the U.S. Census Bureau. Analyses primarily focused on people who worked weekdays.

Results: Sleep time declined with age, to a low at age 45-54 years, when work time and pay were high. Only five of seventeen waking activity categories were related to sleep time—in order of influence: (1) work and work-related activities; (2) time for traveling; (3) socializing, relaxing and leisure time; (4) household activities; (5) time spent on caring for household members. As these activities increased, sleep time decreased (adjusted $r^2 = 0.464$). These relationships were found for both women and men, despite substantial sex differences in time spent at work, on household activities and care of household members, in leisure time, sleeping, eating and drinking, and pay.

Conclusion: Work time and travel time, and to a lesser extent, domestic chores and leisure time, are the primary activities working adults appear to exchange for sleep time.

Key words: time use, sleep, work, travel, commute, household, leisure, child care

Introduction

Biomedical and behavioral research has increasingly demonstrated that the daily need for and timing of sleep is critical for the integrity of waking alertness and cognitive functions[1] and very likely for the maintenance of health[2]. Although human sleep need is instantiated in brain mechanisms and our daily sleep-wake cycle is regulated neurobiologically by a circadian clock,[3] which has its origins in Earth's fundamental orbital rotation on its axis, modern humans frequently alter the timing and duration of sleep in exchange for other activities. This appears to be especially the case in current industrialized societies, where the biological imperative for sleep can be in opposition to the cultural imperative for wakefulness.[4] We theorize that in modern industrialized societies, where there are extensive options and demands on the use of time both day and night, sleep is perceived as a flexible commodity, and sleep time is traded for other activities considered more imperative or of greater value.

Despite the importance of understanding how sleep timing can be influenced by waking activities, there have been few systematic investigations of possible reciprocal relationships between sleep time and waking time for specific types of activity. It has been shown in a time use study that unmarried individuals and those with less than a college education are significantly more likely to sleep a short amount or a long amount compared to married people and college-educated people.[5] Short sleeping and long sleeping (i.e., sleep durations below 7 hours and above 8 hours, respectively) have been found to be associated with increased mortality[6] and a greater risk of coronary heart disease and mortality[7]in epidemiological studies. Sleep quality—especially sleeplessness (insomnia)—has also been found to associated with increased risk of

cardiovascular morbidity and mortality.[8-10] The increased prevalence of obesity in American society is a growing health risk that is associated with sleep duration among adult Americans. As with morbidity and mortality, both shorter sleep durations (<7.5h) and longer durations (>8h) have been associated with larger body mass, suggesting that sleep restriction could be contributing to the increased prevalence of obesity in American society.[6,11,12] These findings raise the possibility that restriction and extension of sleep time may be contributing to the current obesity epidemic in the U.S.

Whether or not life-style mediated alterations of sleep duration are involved in obesity and mortality, there is relatively strong evidence that sleep restriction is a major contributor to errors, accidents and accidental death, especially in transportation modes.[13-17] Concern that inadequate sleep time was leading to chronic sleep restriction and its resulting performance deficits (and therefore to increased risks of crashes) has become a major issue in the U.S. relative to proscriptive work rules and fatigue management, and it has prompted the National Transportation Safety Board to repeatedly call for updated hours-of-service regulations in all modes of transportation.[18] The source of concern about rest times stems from recent studies showing that chronic restriction of sleep to 7 hours or less a day consistently resulted in impairments of attention and psychomotor responses, and these impairments accumulated across consecutive days of sleep restriction to very severe levels.[19-21] Analyses of the relationships between work hours and sleep hours could help inform the public policy debate about how to ensure workers in regulated industries obtain adequate sleep.

We used the American Time Use Survey (ATUS)[22] to evaluate the relationship between sleep time, work time and various other waking behaviors, to provide insights

into the aforementioned public health and public safety issues. Specifically, we used the ATUS database to evaluate precisely which activities have a reciprocal relationship to sleep time, and which do not.

Methods and Procedures

American Time Use Survey. The ATUS database for the year 2003 was used to conduct the investigation. “ATUS is a federally administered, continuous survey on time use in the United States. The goal of the survey is to measure how people divide their time among life’s activities. ATUS interviews randomly selected individuals from a subset of the households that complete their eighth and final month interviews for the Current Population Survey (CPS). ATUS respondents are interviewed only one time about how they spent their time on the previous day, where they were, and whom they were with. The survey is sponsored by the Bureau of Labor Statistics and is conducted by the U.S. Census Bureau. The major purpose of ATUS is to develop nationally representative estimates of how people spend their time…. In addition to collecting data about what people did on the day before the interview, ATUS collects information about where and with whom each activity occurred, and whether the activities were done for one’s job or business. Demographic information—including sex, race, age, educational attainment, occupation, income, marital status, and the presence of children in the household—also is available for each respondent. Although some of these variables are updated during the ATUS interview, most of this information comes from earlier CPS interviews, as the ATUS sample is drawn from a subset of households that completed the CPS.”[22,23]

ATUS is a telephone survey in which people are interviewed one time for 15-20 minutes on a pre-selected day (days are selected to ensure that the survey captures activities every day in the year). Subjects' participation in the 2003 survey that we used was voluntary, and they were compensated $40 for completing the survey. ATUS covers all residents living in households in the United States who are at least 15 years of age, with the exception of active military personnel and people residing in institutions such as nursing homes and prisons. The survey was conducted by the U.S. Census Bureau for the Department of Labor's Bureau of Labor Statistics. Section 9 of Title 13, United States Code, ensures that all information about obtained via ATUS strictly maintains the confidential of the respondents and their households. The U.S. Office of Management and Budget (OMB) approved the survey.[23]

The ATUS sample was drawn from the CPS, which is composed of the approximately 105 million households in the United States and the civilian, non-institutional population residing in those households. The ATUS sample was a stratified, three-stage sample. In the first stage of selection, the CPS over-sample in the less-populous States was reduced. In the second stage of selection, households were stratified based on the following characteristics: the race/ethnicity of the householder, the presence and age of children, and the number of adults in adults-only households. In the third stage of selection, an eligible person from each household selected in the second stage was randomly selected to be the designated person for ATUS. In 2003, 3,375 households leaving the CPS sample were selected for the ATUS sample each month (approximately 40,500 households). The ATUS overall response rate averaged 57 percent in 2003. The database analyzed contained 20720 respondents. Full details

of the sampling methodology and data categorizing are publicly available at the ATUS website.[22, 23]

All ATUS interviews were conducted from the U.S. Census Bureau's telephone center at the National Processing Center in Jeffersonville, IN. The interviewers attempted calls in four call blocks throughout the day and were required to make at least one call in each call block until contact was made with each household. The call blocks were 09:00 to 11:59, 12:00 to 16:59; 17:00 to 20:59, and 21:00 to 00:00. Calls were not made between the hours of 00:00 and 08:59. The center used an automated call scheduler, which tells the interviewers when each household should be called. Once a household was contacted and the designated person agreed to complete the interview, the interviewer conducted the interview using computer-assisted telephone interviewing (CATI).[23] When contacted by phone, respondents were asked about the activities they engaged in going back 24 hours. Responses were codified using the ATUS coding lexicon, or activity classification system, which is a three-tiered system, with 17 major, or first-tier, categories, each having two additional levels of detail (tiers). Each third-tier activity category also contained a list of examples of activities that fall into that category.[24]

Codification of activity in ATUS. The 17 different broad categories of activity codified from ATUS are listed below, along with the second-tier activities. As examples, third-tier activities are only provided for "sleeping" and "sleeplessness." Coders at the telephone center assigned a six-digit classification code to each diary activity reported by a respondent. The first two digits represented the major activity category; the next

two digits the second-tier level of detail; and the final two digits represent the third, most detailed level of activity.[23] For example, the ATUS code for “sleeping” is 01.01.01.

1st tier: 01 Personal Care. 2nd tier: 01 Sleeping (3rd tier: 01 Sleeping [sleeping, falling asleep, dozing off, napping, getting up, waking up, dreaming, cat napping, getting some shut-eye, dozing]; 02 Sleeplessness [insomnia, tossing and turning, lying awake, counting sheep]; 99 Sleeping [not elsewhere classified]); 02 Grooming; 03 Health-related Self Care; 04 Personal Activities; 05 Personal Care Emergencies; 99 Personal Care not elsewhere classified.

02 Household Activities. 01 Housework; 02 Food and Drink Preparation, Presentation, and Clean-up; 03 Interior Maintenance, Repair, and Decoration; 04 Exterior Maintenance, Repair, and Decoration; 05 Lawn, Garden, and Houseplants; 06 Animals and Pets; 07 Vehicles; 08 Appliances and Tools; 09 Household Management; 99 Household Activities not elsewhere classified.

03 Caring For and Helping Household Members. 01 Caring For and Helping Household Children; 02 Activities Related to household Children's Education; 03 Activities Related to household Children's Health; 04 Caring For Household Adults; 05 Helping Household Adults; 99 Caring For and Helping household Members not elsewhere classified.

04 Caring For and Helping Nonhousehold Members. 01 Caring For and Helping Nonhousehold Children; 02 Activities Related to Nonhousehold Children's Education; 03 Activities Related to Nonhousehold Children's Health; 04 Caring For Nonhousehold Adults; 05 Helping Nonhousehold Adults; 99 Caring For and Helping Nonhousehold Members not elsewhere classified.

05 Working and Work-Related Activities. 01 Working; 02 Work-Related Activities; 03 Other Income-generating Activities; 04 Job Search and Interviewing; 99 Work and Work-Related Activities not elsewhere classified.

06 Education. 01 Taking Class; 02 Extracurricular School Activities—Except Sports; 03 Research/Homework; 04 Registration/Administrative activities; 99 Education not elsewhere classified.

07 Consumer Purchases. 01 Shopping—Store, Telephone, Internet; 02 Researching Purchases; 03 Security Procedures Related to Consumer Purchases; 99 Consumer Purchases not elsewhere classified.

08 Professional and Personal Care Services. 01 Childcare Services; 02 Financial Services and Banking; 03 Legal Services; 04 Medical and Care Services; 05 Personal Care Services; 06 Real Estate; 07 Veterinary Services; 08 Security Procedures Related to Professional/Personal Services; 99 Professional and Personal Services not elsewhere classified.

09 Household Services. 01 Household Services (not done by self); 02 Home Maintenance, Repair, Decoration, and Construction (not done by self); 03 Pet Services (not done by self, not vet); 04 Lawn and Garden Services (not done by self); 05 Vehicle Maintenance and Repair Services (not done by self); 99 Household Services not elsewhere classified.

10 Government Services and Civic Obligations. 01 Using Government Services; 02 Civic Obligations and Participation; 03 Waiting Associated with Government Services or Civic Obligations; 04 Security Procedures Related to Government Services/Civic Obligations; 99 Government Services not elsewhere classified.

11 Eating and Drinking. 01 Eating and Drinking; 99 Eating and Drinking not elsewhere classified.

12 Socializing, Relaxing, and Leisure. 01 Socializing and Communicating; 02 Attending or Hosting Social Events; 03 Relaxing and Leisure; 04 Arts and Entertainment other than sports; 05 Waiting Associated with Socializing, Relaxing, and Leisure; 99 Socializing, Relaxing, and Leisure not elsewhere classified.

13 Sports, Exercise, and Recreation. 01 Participating in Sports, Exercise, or Recreation; 02 Attending Sporting/Recreational Events; 03 Waiting Associated with Sports, Exercise, and Recreation; 04 Security Procedures Related to Sports, Exercise, and Recreation; 99 Sports, Exercise, and Recreation not elsewhere classified

14 Religious and Spiritual Activities. 01 Religious/Spiritual Practices; 99 Religious and Spiritual Activities not elsewhere classified.

15 Volunteer Activities. 01 Administrative and Support Activities; 02 Social Service and Care Activities (Except Medical); 03 Indoor and Outdoor Maintenance, Building, and Clean-up Activities; 04 Participating in Performance and Cultural Activities; 05 Attending Meetings, Conferences, and Training; 06 Public Health and Safety Activities; 99 Volunteer Activities not elsewhere classified.

16 Telephone Calls. 01 Telephone Calls; 99 Telephone Calls not elsewhere classified.

17 Traveling. 01 Travel Related to Personal Care; 02 Travel Related to Household Activities; 03 Travel Related to Caring For and Helping household Members; 04 Travel Related to Caring For and Helping Nonhousehold Members; 05 Travel Related to Work; 06 Travel Related to Education; 07 Travel Related to Consumer

Purchases; 08 Travel Related to Using Professional and Personal Care Services; 09 Travel Related to Using Household Services; 10 Travel Related to Using Government Services and Civic Obligations; 11 Travel Related to Eating and Drinking; 12 Travel Related to Socializing, Relaxing, and Leisure; 13 Travel Related to Sports, Exercise, and Recreation; 14 Travel Related to Religious/Spiritual Activities; 15 Travel Related to Volunteer Activities; 16 Travel Related to Telephone Calls; 17 Security Procedures Related to Traveling; 99 Traveling not elsewhere classified.

Results

Data analyses focused on the relationships between sleep and various waking activities.

Sleep time in relation to age and sex. Sleep time (01.01.01) was first evaluated for its relationship to age in both males and females. Age data were binned into 5-year and 10-year blocks starting at age 15 years and continuing to a category for ages 65 and higher. Figure 1 displays the mean sleep times for 20684 respondents (11650 females and 9034 males) by age category. Sleep time declined from adolescence (15-19 years) to ages 45-54 years then increased again. Teenage (15-19 year old) girls slept somewhat less than boys, but sleep time for men was less than women by an average of 10 minutes per day between the ages of 20 and 64 years (Table 1).

Insert Figure 1 here

Since work-related activities were among the factors hypothesized to be most reciprocally related to sleep time, analyses were confined to the 5406 people who were 25-64 years of age, and who worked during weekdays for fiscal compensation.[1] In this

[1] We precluded ages 15-24 years and 65 years or older from these analyses in order to focus analyses on working adults.

cohort men also slept a daily average of 10 minutes less than women (p = 0.0005). As seen in Table 1, men's work and work-related activities (05.01+02.all)[2] averaged 8.40 hours (SD = 2.83h), which was 1 hour and 3 minutes more than women (p = 0.0001), who worked 7.36 hours (SD = 2.76h). In contrast, proportionally more women (83.1%) than men (62.5%) worked on household activities (02.all.all),[3] and among those who did, women worked an average of 24 minutes longer per day more than men (p=0.0001). Similarly, proportionally more women (42.4%) than men (30.9%) cared for household members (03.all.all), and among those who did, women did so an average of 24 minutes more than men (p=0.0001).

Although women slept an average of 10 minutes more than men, men spent an average of 20 minutes more a day socializing, relaxing and doing leisure activity than did women (p = 0.0001), and an average of 5 minutes more a day eating and drinking (p = 0.004). Table 1 displays these differences.

Insert Table 1 here

Sleep and work time. Figure 2 displays mean sleep time (01.01.01) and mean work time (05.01+02.all) across age categories for the 7637 people who reported working. Within each age category, average work time was plotted as a function of average sleep time for each of seven sleep time bins (<5h, 5.5h±0.5h, 6.5h±0.5h, 7.5h±0.5h, 8.5h±0.5h, 9.5h±0.5h, ≥10h). Figure 3 shows these plots along with the r^2 value from the linear regression fit to the data points within each age category. It is clear that at every age, the less time devoted to sleep, the more time devoted to work. Figure

[2]Tier 1 = category 05 (Working and Work-related Activities); tier 2 = categories 01 (working) and 02 (work-related activities); tier 3 = all categories)
[3]Tier 1 = category 02 (Household Actvities); tier 2 = all categories; tier 3 = all categories.

4 presents the relationship between average work time and average sleep bin for all 4749 respondents between the ages 25-64 years who worked on weekdays. With each 1-hour reduction in sleep time, work time increased by 28.96 minutes. Results for women and men are also shown separately. While both groups showed the relationship of reduced sleep and increased work time, the effect was somewhat more pronounced among men. These data included n=110 interviewees who reported sleeplessness (01.01.02). When these subjects were removed, there was no change in the reciprocal relationship between time spent working and time spent sleeping (Figure 5).

Insert Figures 2, 3, 4, 5 here

Sleep time and weekly income. Figure 6 shows the mean income for 11934 respondents (6226 females and 5608 males) by age category. Income increases steadily from adolescence to ages 45-54 years, then decreases. The pattern is evident in both men and women, despite men being paid much more per week than women. The profile in Figure 6 looks like the inverse of the relationship between sleep time and age category (Figure 1), despite the latter being confined to only those interviewees who reported being paid. Not surprisingly, weekly pay increased with work hours—especially in women—but this relationship did not hold for smaller percentage of men working less than 6.5 hours (Figure 7).

The relationship between weekly pay and sleep time bin was also linear across sleep times—only in this case, as sleep decreased, pay increased (Figure 8). For each 1-hour decrease in sleep time, weekly pay increased by $40. However, when sleep time was below 6.5 hours, pay ceased to increase.

Insert Figures 6, 7, 8 here

Sleep time and travel time. The relationship between mean traveling time (17.all.all) and mean sleep time (by bin) is shown in Figure 9 for weekday workers aged 25-64 years. As sleep time decreased, travel time increased, with no differences evident between women and men. Figure 10 shows this reciprocal relationship is near-linear across sleep time bins. Thus, for each 1-hour decrease in sleep time, time spent on travel increased by 9.84 minutes.

Since the traveling category includes all types of travel, the analyses were confined to commute time (Figure 11). The same linear relationship was observed—commute time increased as sleep time decreased, such that for each 1-hour decrease in sleep time, commute time increased by 2.69 minutes.

Insert Figures 9, 10, 11 here

Sleep time and social/leisure time. The relationship between socializing, relaxing and leisure time (12.all.all) and sleep time (01.01.01) is shown in Figure 12. Although leisure time increased as sleep time decreased, this was only the case when sleeping time was below 7.5 hours, which involved 31% of the 4363 weekday workers aged 25-64 years. Thus, for each 1-hour decrease in sleep time, time spent socializing, relaxing and at leisure increased by 7.77 minutes.

Insert Figure 12 here

Sleep time and other activities at home. Household activities (02.all.all), and caring for and helping household members (03.all.all)—two activity categories in which women spend more time than men (Table 1)—showed no systematic relationship to sleep time (01.01.01), as seen in Figures 13 and 14. In general, time for these activities

increased only when sleep time was below 5 hours and this represented less than 7% of respondents.

All remaining11 ATUS tier 1 activity categories showed no systematic relationship to sleep time in adult weekday workers. These categories were: caring for and helping non-household members (04.all.all); education (06.all.all); consumer purchases (07.all.all); professional and personal care services (08.all.all); household services (09.all.all); government services and civic obligations (10.all.all); eating and drinking (11.01.all); sports, exercise, recreation (13.01.all); religious and spiritual activities (14. all.all); volunteer activities (15.all.all); telephone calls (16.all.all).

Insert Figures 13 and 14 here

Modeling sleep time. Stepwise regression was used to construct models of sleep time for weekday workers aged 25-64 years. Data were analyzed without being binned for sleep time category. A model involving 2875 respondents and accounting for 35.6% of the variance in sleep time was comprised of work time, travel time, leisure time, household activities time, and weekly pay (adjusted $r^2 = 0.356$). A second model involving 1192 respondents and accounting for 46.4% of the variance in sleep time was comprised of work time, travel time, household activities time, leisure time, time spent caring for other household members, and age (adjusted $r^2 = 0.464$). Consistent with binned data shown in Figures 4, 5, 8, 9, 10, and 11, in all stepwise regression models, standardized beta coefficients for activity predictors were negative (i.e., more time in each activity was associated with less sleep time), Standardized beta coefficients for model 2 were: work time (-0.847), travel time (-0.513), household activities time (-0.479), leisure time (-0.509), and time spent caring for other household members

(-0.411). Age also had a negative, albeit quite modest, standardized beta coefficient (-0.087), indicating that older age was associated with less sleep time, consistent with Figure 1.

None of the other dozen ATUS time use categories were associated systematically with sleep time in weekday workers.

Discussion

We used the American Time Use Survey 2003 database to evaluate the theory that sleep time is perceived as a flexible temporal commodity that can be traded for waking activities considered either more imperative or of greater value. We opted to address these issues primarily among survey respondents who were engaged in weekday work schedules.

Across the age span from 15 to 65+ years, sleep time reached a minimum at age 45-54 years (Figure 1), which was also a period of greater work time (Figure 2) and higher pay (Figure 6). More than any other factor, time used for work and work-related activities (ATUS tier 1 category 5) was consistently associated with sleep time (ATUS category 01.01.01), such that work time increased as sleep time declined. This fundamental linear relationship was found at all ages (Figure 3), and for both sexes (Figure 4). Not surprisingly, weekly pay increased both with increased work time (Figure 7) and with decreased sleep time (Figure 8). Collectively, these findings suggest that it is the economic incentive of work time that may play a key role in reducing sleep time.

Time for traveling (ATUS tier 1 category 17) was second only to work time in regression modeling of sleep time. While work time was hypothesized to have a negative relationship to sleep time, we did not anticipate the importance of trave time as

a possible negative influence on sleep time. Traveling time did not vary by sex (Figure 9), but it had a clearly negative linear association with sleep time for the entire travel category (Figure 10) and for commute time only (Figure 11). Traveling time included travel for virtually any reason. Continued growth of travel by land, sea and air; declining capacities of roadways, runways and railways; and urban sprawl are likely some of the factors that have contributed to increased travel time.

Three other ATUS tier 1 categories were partially associated with sleep time. Socializing, relaxing and leisure time (ATUS tier 1 category 12) was negatively related to sleep time, but this relationship was primarily evident for sleep time less than 7.5 hours (Figure 12); for each 1-hour decrease in sleep time, time spent socializing, relaxing and at leisure increased by 7.77 minutes. Similar results were obtained for household activities (ATUS tier 1 category 2)—which included housework; food and drink preparation and clean-up; interior and exterior maintenance; lawn, garden, and houseplants; animals and pets; vehicles; appliances and tools; and household management. The relationship to sleep time was negative for sleep time less than 6.5 hours (Figure 13). Time spent on caring for household members (ATUS tier 1 category 3) was negatively related to sleep time only for sleep below 5 hours (Figure 14).

Remarkably, none of the other 11 ATUS tier 1 categories were systematically related to sleep time in employed adults with weekday jobs. This may have to do the relative temporal infrequency or lower duration of time people devoted to these other categories. That is, more focused analyses on people who reported activities that were less frequent (e.g., volunteer activities; consumer purchases; religious and spiritual activities), may reveal reciprocal relationships between these activities and sleep time.

Whatever the reasons, these 11 other ATUS activity categories were inconsequential in the larger cohort compared to the five factors most associated with reduced sleep time, which were work time, travel time, household activities time, leisure time, and time spent caring for other household members—in that order of influence.

Despite substantial sex differences in time use for sleep, work, household activities, care of household members, leisure time, time for eating and drinking (Table 1), and pay (Figures 6-8), the relationships between the five key categories of time use described above and sleep time were relatively equivalent between adult weekday-employed women and men, resulting in sex playing little to no appreciable role in predictive modeling. Men worked on the job an average of 63 minutes more a day than women, but women spent an average of 48 minutes a day more than men on household duties and care of household members (and proportionally more women than men reported these activities). Men had an average of 20 minutes more a day for socializing, relaxing and leisure than women, while women had an average of 10 minutes more sleep time a day than men. The fact that women and men between the ages of 25 and 64 years differed in time spent on activities that were negatively associated with sleep time, suggests that men and women exchange sleep time somewhat differently for waking activities deemed imperative or of value.

This study has a number of limitations. The values for sleep time may overestimate actual sleep obtained by respondents because the ATUS Activity Lexicon 2003 permitted codification as sleep of words that reflected transition states (e.g., falling asleep, dozing off, getting up, waking up).

The inherently cross-sectional nature of the data limits conclusions of causality. We cannot be certain that sleep time is reduced deliberately to increase work time or income. It is possible that survey respondents were reporting the sleep as a reflection of their biological sleep need (as represented by a normal distribution), and that the increased time we observed for work, travel and other activities was purely at their discretion (i.e., all waking activities are equally valued). We doubt this interpretation is correct because of the relatively few waking activities that were reciprocally related to sleep time, and because there is ample evidence that people can and do engage in lifestyles that result in sleep restriction and its adverse consequences for neurobehavioral functions, safety and health.[6-17]

The findings of the current study point to work time, travel time, domestic chores (household activities and caring for household members) and leisure as the primary activities exchanged for sleep time. A regression model established that these factors accounted for 46.4 percent of the variance in sleep time in weekday-working adults. Considerably more research is required to identify how these and other factors influence sleep timing, duration, and quality. It is especially important to determine at what point the exchanges people make between sleep time and time for other activities can result in adverse consequences for health and safety.

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24. American Time Use Survey Activity Lexicon, November 2004. (2003) This document is the activity classification scheme (including examples) used to code activities collected during the American Time Use Survey into time-use categories. Bureau of Labor Statistics. See http://www.bls.gov/tus/lexiconwex2003.pdf

Table 1. Activities of employed women and men between the ages of 25 and 64 years, who worked on weekdays.

	Women			Men				
Activities	**n**	**mean***	**SD**	**n**	**mean**	**SD**	**Difference**	**P**
Sleep[1]	2648	7.68	1.67	2758	7.51	1.67	0h 10min	0.0005
Work[2]	2651	7.35	2.76	2764	8.40	2.83	1h 03min	0.0001
Household activities[3]	2202	1.63	1.51	1728	1.23	1.32	0h 24min	0.0001
Care for household members[4]	1123	1.55	1.48	853	1.15	1.19	0h 24min	0.0001
Socializing, relaxing, leisure[5]	2429	2.69	1.80	2564	3.02	1.98	0h 20min	0.0001
Eating and drinking[6]	2414	1.06	0.70	2589	1.14	0.69	0h 5min	0.004

*hours
[1]Tier codes: 01.01.all
[2]Tier codes: 05.01+02.all
[3]Tier codes: 02.all.all
[4]Tier codes: 03.all.all
[5]Tier codes: 12.all.all
[6]Tier codes: 11.01.all

Figure Captions

Figure 1. Mean sleep time (01.01.01) as a function of age group for 11650 females, 9034 males, and the total (20684) who reported sleep.

Figure 2. Mean sleep time (01.01.01) and mean work time (05.01+02.all) across age category for the 7637 people who reported working.

Figure 3. Mean work time (05.01+02.all) plotted relative to mean sleep time (01.01.01) bin within each age category for the 7339 people who reported work time and sleep time within each of the six age categories ≥20 years. Average sleep time was derived for seven sleep time bins (<5h, 5.5h±0.5h, 6.5h±0.5h, 7.5h±0.5h, 8.5h±0.5h, 9.5h±0.5h, ≥10h). The r^2 value on each graph was derived from a linear regression fit to the data points within each age category.

Figure 4. Relationship between average work time and average sleep time bin for all 4749 people between the ages 25-64 years who worked on weekdays, as well as separately for the 2323 women and 2426 men who made up this total. Percentages indicate the proportion of men and women who contributed to each point. Linear regression on the total sample yielded $y = 0.4827x$ ($r^2 = 0.959$). Thus, for 1-hour decrease in sleep time, work time increased by 28.96 minutes.

Figure 5. Relationship between average work time and average sleep time bin for all 6613 subjects between the ages 25-64 years who reported working (graph A), and for all subjects excluding the n=110 who reported sleeplessness (graph B) as identified by 01.01.02. The exclusion of the latter had no appreciable effect on the relationship.

Figure 6. Mean pay per week as a function of age group for 6226 females, 5608 males, and the total (11834) who reported sleep.

Figure 7. Weekly pay as a function of work time bins for 4141 weekday workers. Percentages indicate the proportion of men (n=2053) and women (n=2088) who contributed to each point. Linear regression on the total sample yielded y = 65.412x (r^2 = 0.903). Thus, for each 1-hour increase in work time, weekly pay increased by $65. A subgroup of 14% males, who had higher pay for fewer work hours, did not fit this inverse relationship.

Figure 8. Mean weekly pay as a function of sleep time bins for 4134 weekday workers. Percentages indicate the proportion of men (n=2048) and women (n=2086) who contributed to each point. Linear regression on the total sample yielded y = 40.157x (r^2 = 0.677). Thus, for each 1-hour decrease in sleep time, weekly pay increased by $40. However, when sleep time was below 6 hours, pay ceased to increase.

Figure 9. Mean travel time (17.all.all) relative to mean sleep time (01.01.01) bin for 4647 people who worked weekdays (n=2376 men; n=2271 women). There were no differences between women and men.

Figure 10. Mean travel time (17.all.all) relative to mean sleep time (01.01.01) bin for 4647 people who worked weekdays. Linear regression on the total sample yielded y = 0.164x (r^2 = 0.923). Thus, for each 1-hour decrease in sleep time, time spent on travel increased by 9.84 minutes.

Figure 11. Mean commute time related to work (17.05.all) relative to mean sleep time (01.01.01) bin for 4179 people who worked weekdays. Linear regression on the total sample yielded y = 0.0449x (r^2 = 0.883). Thus, for each 1-hour decrease in sleep time, commute time increased by 2.69 minutes.

Figure 12. Relationship between mean time spent socializing, relaxing and at leisure (12.all.all), and sleep time (01.01.01) for 4363 weekday workers aged 25-64 years. Although leisure time increased as sleep time decreased, this was only the case when sleep time dropped below 7 hours, which involved 31% of subjects. Linear regression on the total sample yielded $y = 0.1296x$ ($r^2 = 0.824$). Thus, for each 1-hour decrease in sleep time, time spent socializing, relaxing and at leisure increased by 7.77 minutes.

Figure 13. Relationship between mean time spent on household activities (02.all.all) and sleep time (01.01.01) for 3534 weekday workers aged 25-64 years. Percentages indicate the proportion of men (n=1558) and women (n=1976) who contributed to each point. Although household activity time increased as sleep time decreased, this was only the case when sleep time dropped below 6 hours in women (11%) and below 5 hours in men (5%).

Figure 14. Relationship between mean time spent on caring for household members (03.all.all) and sleep time (01.01.01) for 1974 weekday workers aged 25-64 years. Percentages indicate the proportion of men (n=852) and women (n=1122) who contributed to each point. Although time spent caring for household members time increased as sleep time decreased, this was only the case when sleep time dropped below 5 hours (5% women, 6% men).

Figure 1

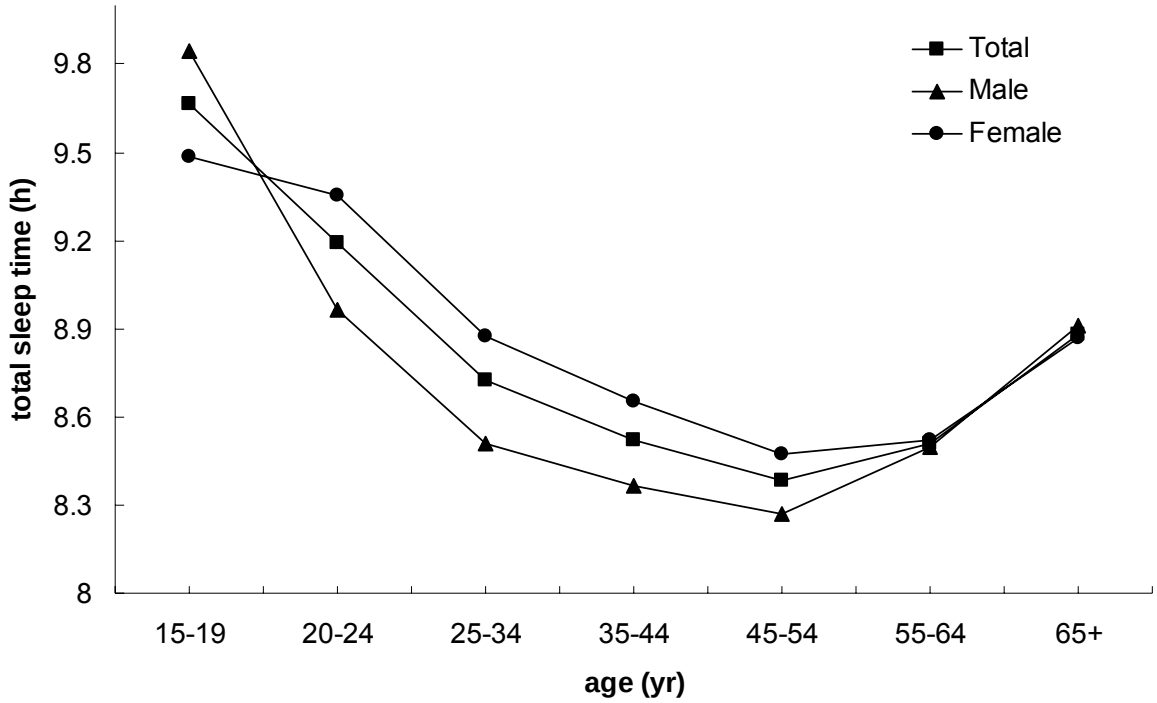

Total
Male
Female
9.8
9.5
9.2
8.9
8.6
8.3
8
total sleep time (h)
15-19
20-24
25-34
35-44
45-54
55-64
65+
age (yr)

Figure 2

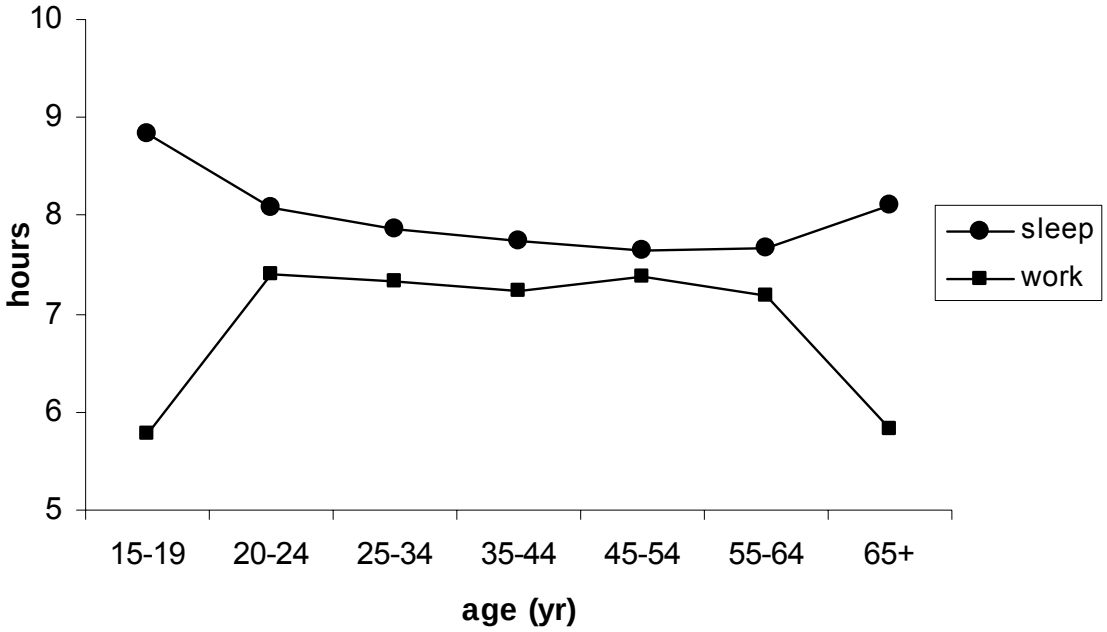

10
9
8
7
6
5
hours
15-19
20-24
25-34
35-44
45-54
55-64
65+
age (yr)
sleep
work

Figure 3

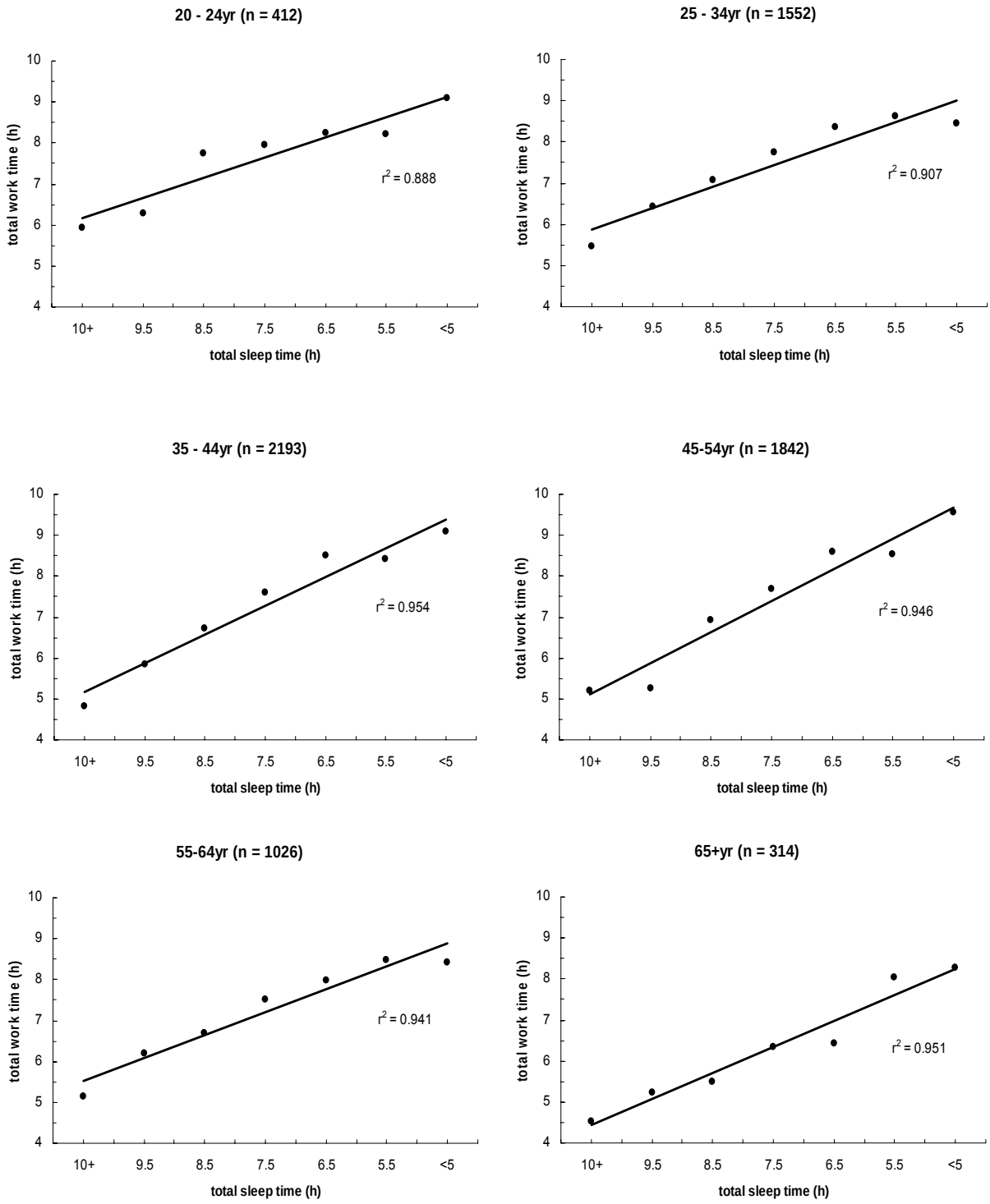

20 - 24yr (n = 412)
25 - 34yr (n = 1552)
35 - 44yr (n = 2193)
45-54yr (n = 1842)
55-64yr (n = 1026)
65+yr (n = 314)
total work time (h)
total sleep time (h)
10+
9.5
8.5
7.5
6.5
5.5
<5
r2 = 0.888
r2 = 0.907
r2 = 0.954
r2 = 0.946
r2 = 0.941
r2 = 0.951

Figure 4

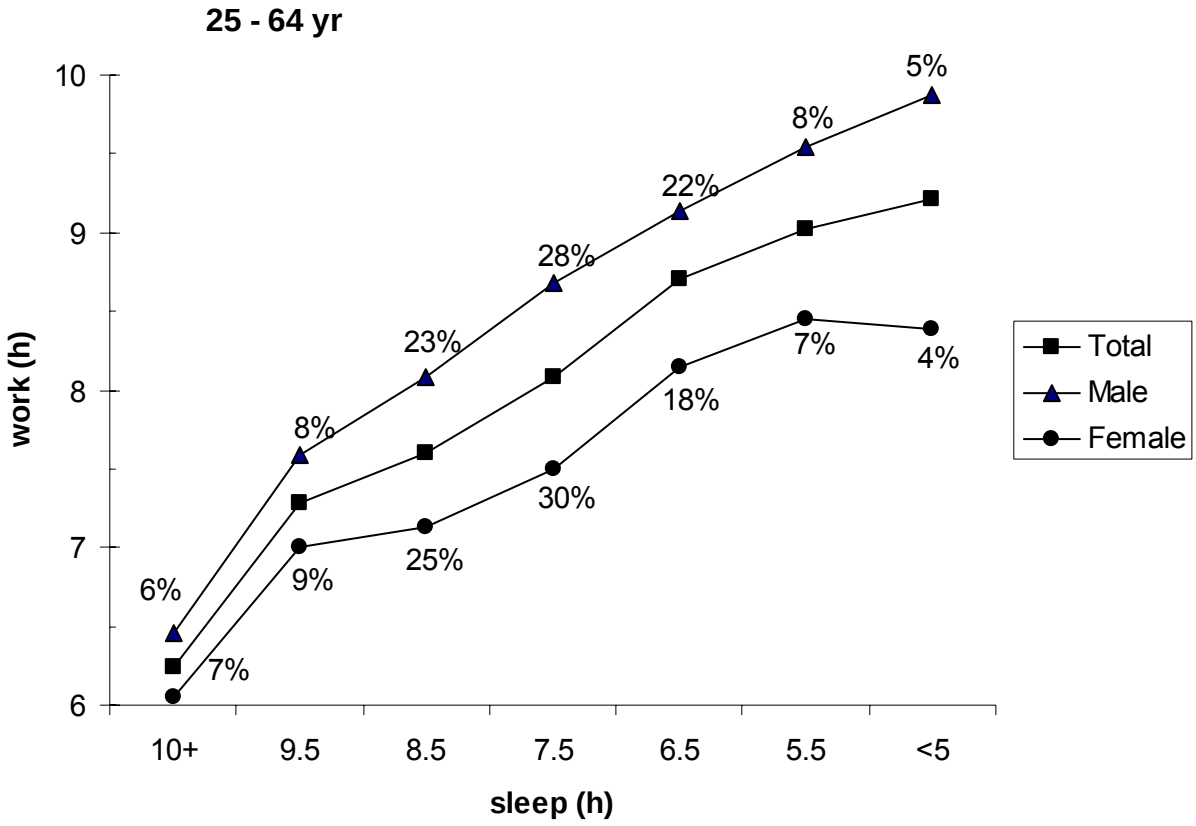

25 - 64 yr
work (h)
10
9
8
7
6
10+
9.5
8.5
7.5
6.5
5.5
<5
sleep (h)
Total
Male
Female
6%
8%
23%
28%
22%
8%
5%
7%
9%
25%
30%
18%
7%
4%

Figure 5

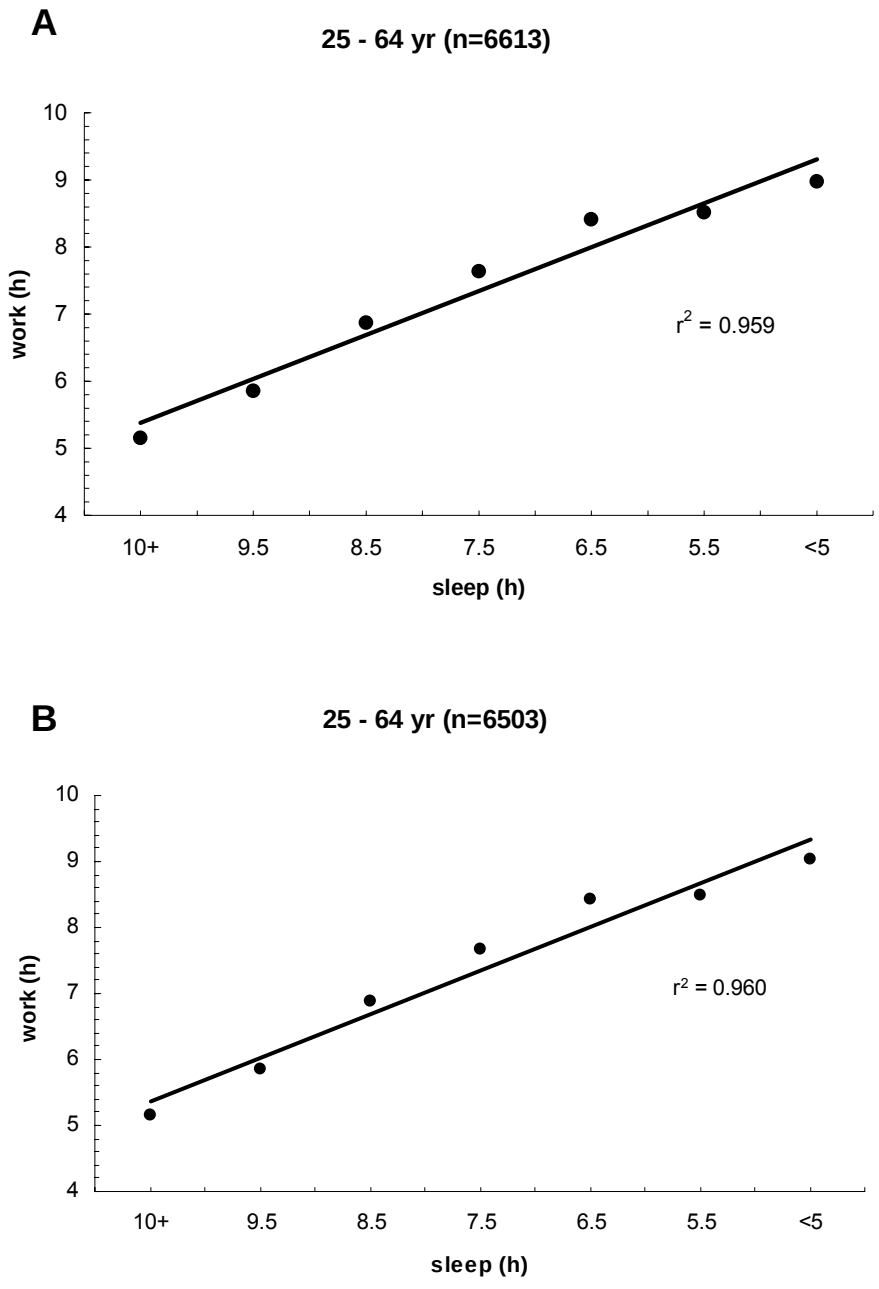

A
25 - 64 yr (n=6613)
work (h)
sleep (h)
r2 = 0.959
10
9
8
7
6
5
4
10+
9.5
8.5
7.5
6.5
5.5
<5
B
25 - 64 yr (n=6503)
work (h)
sleep (h)
r2 = 0.960

Figure 6

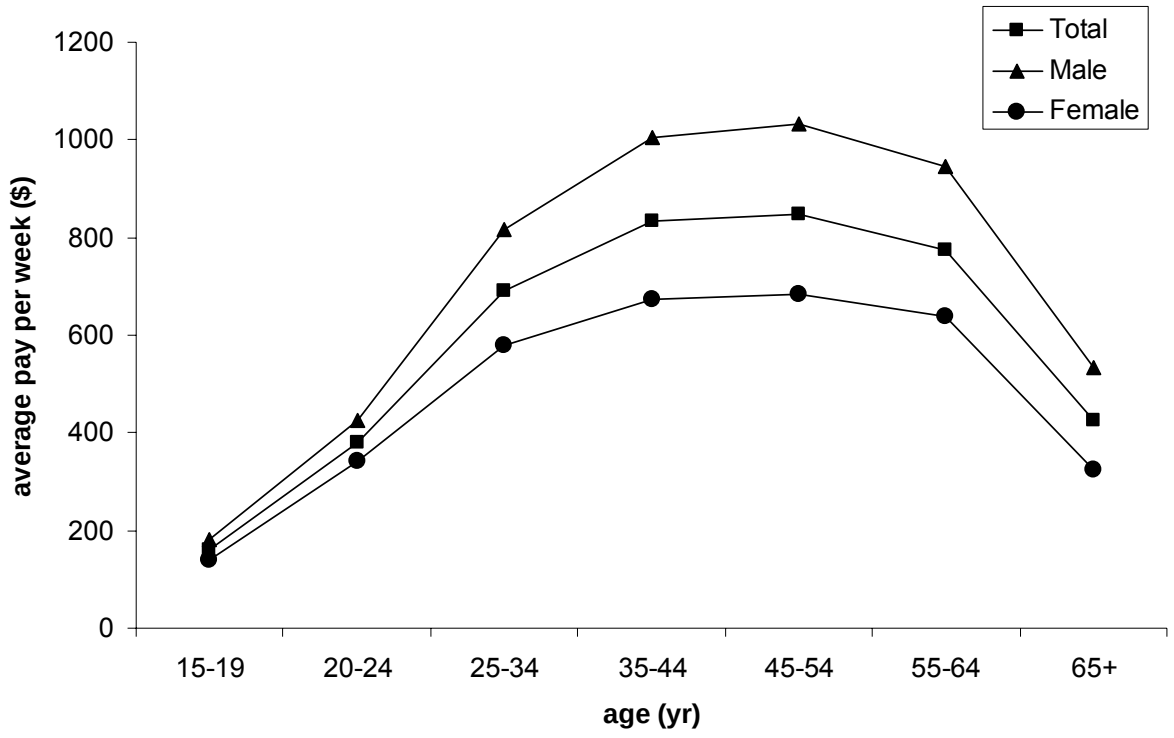

Total
Male
Female
1200
1000
800
600
400
200
0
average pay per week ($)
15-19
20-24
25-34
35-44
45-54
55-64
65+
age (yr)

Figure 7

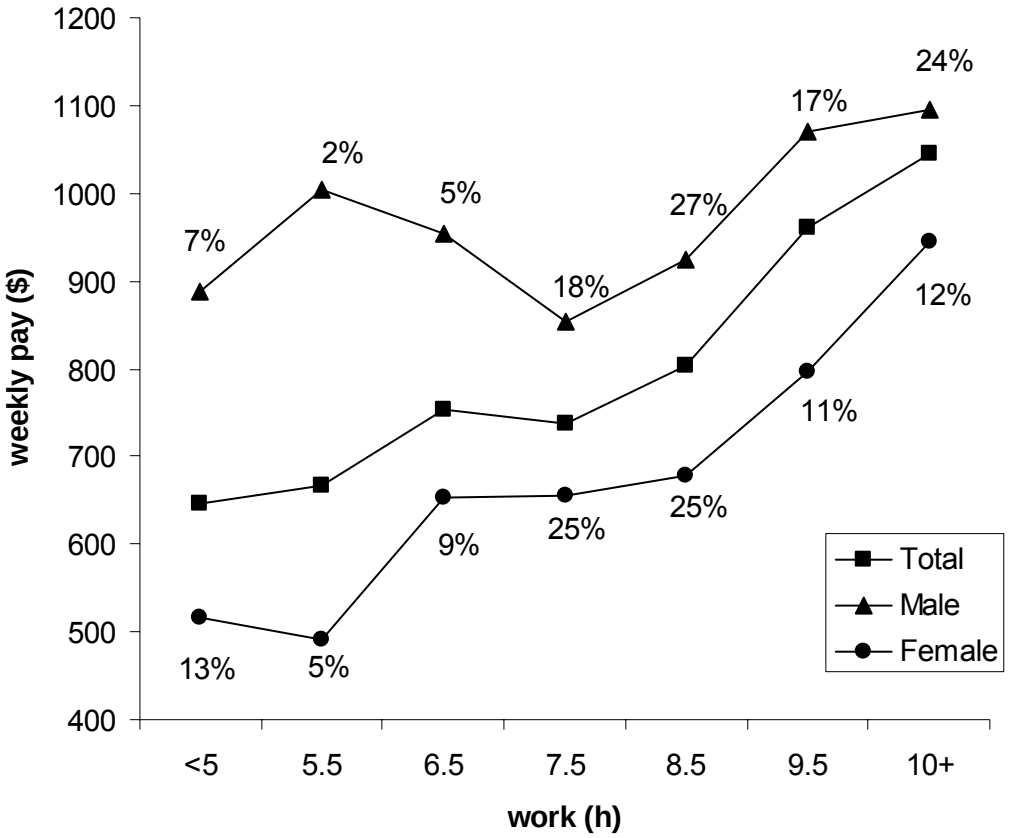

1200
1100
1000
900
800
700
600
500
400
weekly pay ($)
<5
5.5
6.5
7.5
8.5
9.5
10+
work (h)
7%
2%
5%
18%
27%
17%
24%
13%
5%
9%
25%
25%
11%
12%
Total
Male
Female

Figure 8

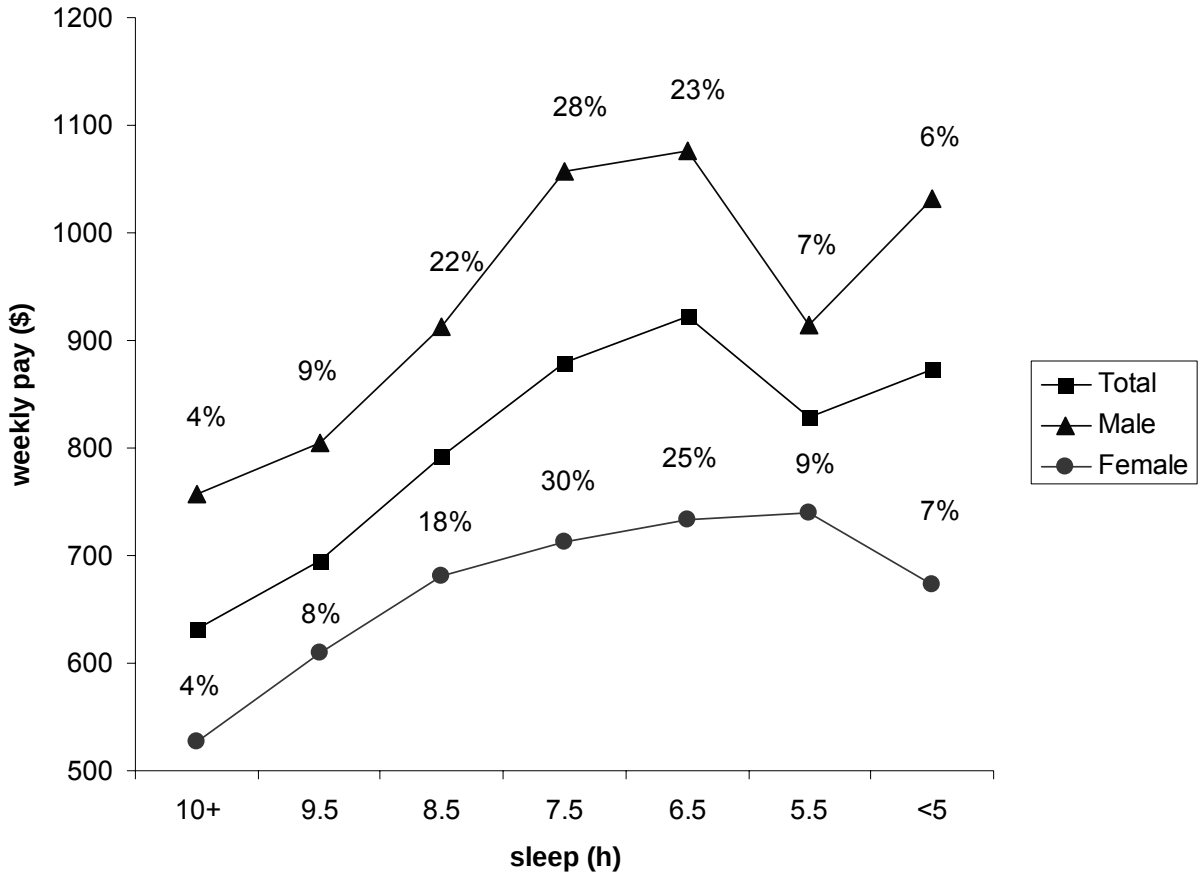

1200
1100
1000
900
800
700
600
500
weekly pay ($)
10+
9.5
8.5
7.5
6.5
5.5
<5
sleep (h)
4%
9%
22%
28%
23%
7%
6%
4%
8%
18%
30%
25%
9%
7%
Total
Male
Female

Figure 9

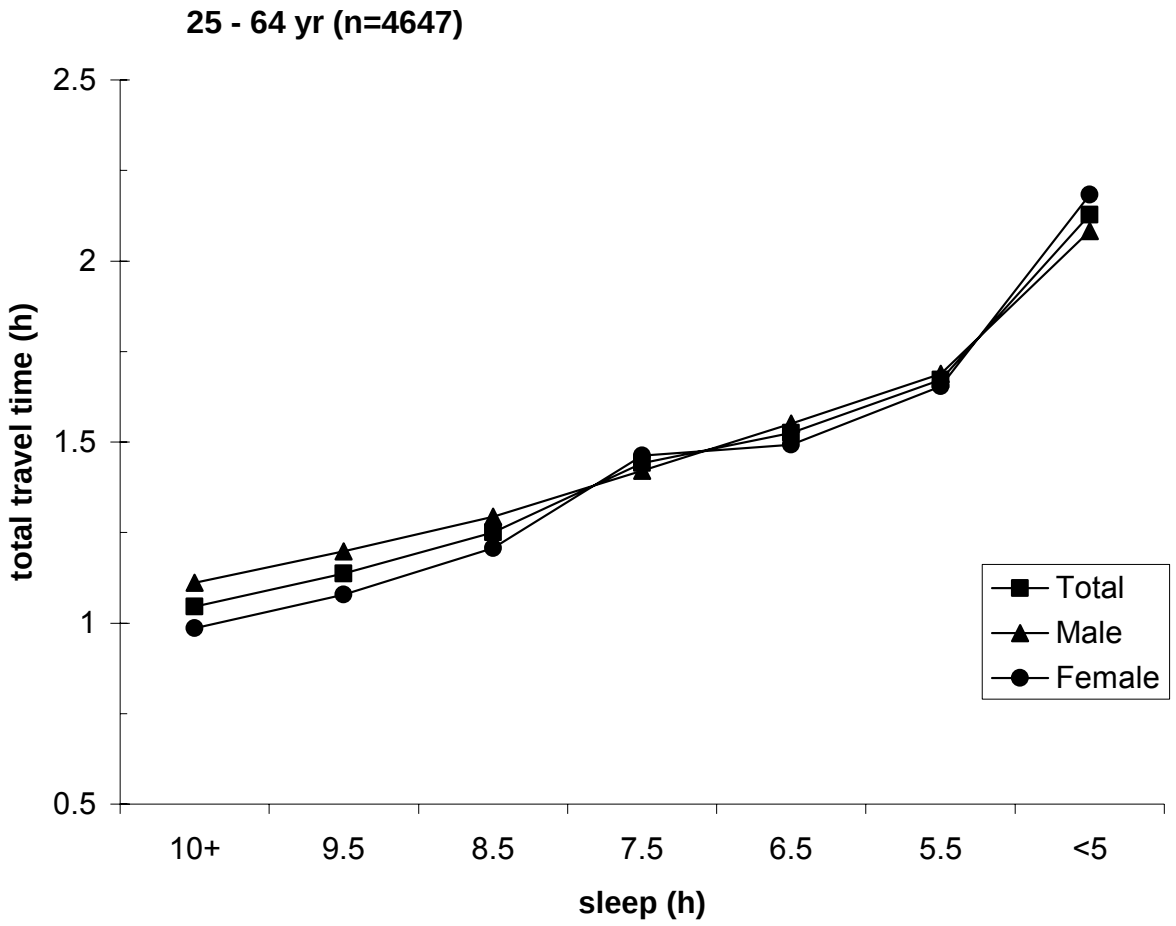

25 - 64 yr (n=4647)
total travel time (h)
2.5
2
1.5
1
0.5
10+
9.5
8.5
7.5
6.5
5.5
<5
sleep (h)
Total
Male
Female

Figure 10

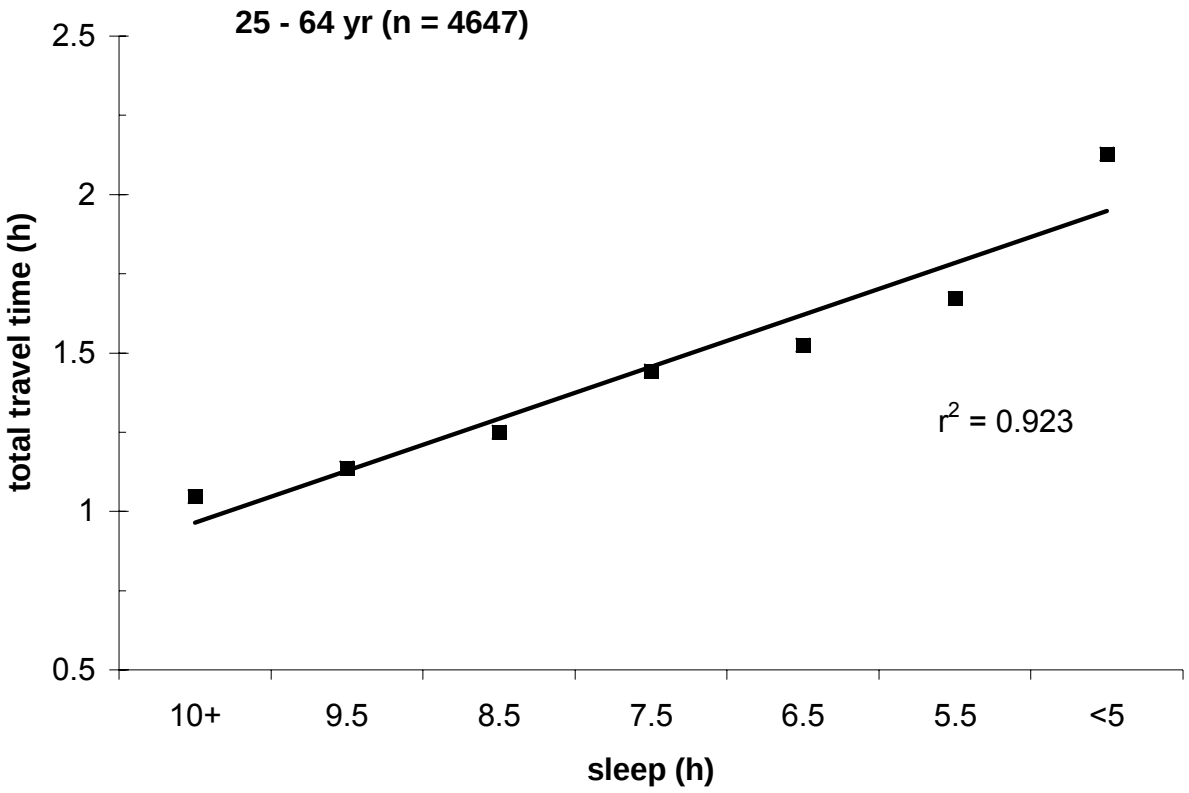

25 - 64 yr (n = 4647)
2.5
2
1.5
1
0.5
total travel time (h)
r^2 = 0.923
10+
9.5
8.5
7.5
6.5
5.5
<5
sleep (h)

Figure 11

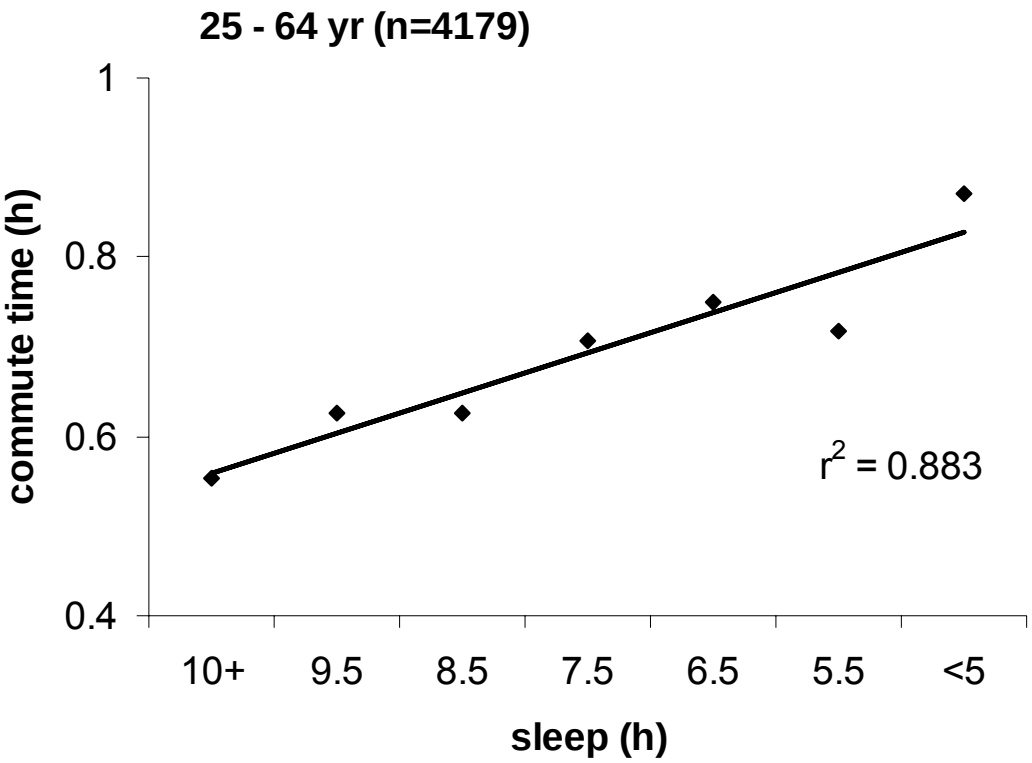

25 - 64 yr (n=4179)
commute time (h)
1
0.8
0.6
0.4
r^2 = 0.883
10+
9.5
8.5
7.5
6.5
5.5
<5
sleep (h)

Figure 12

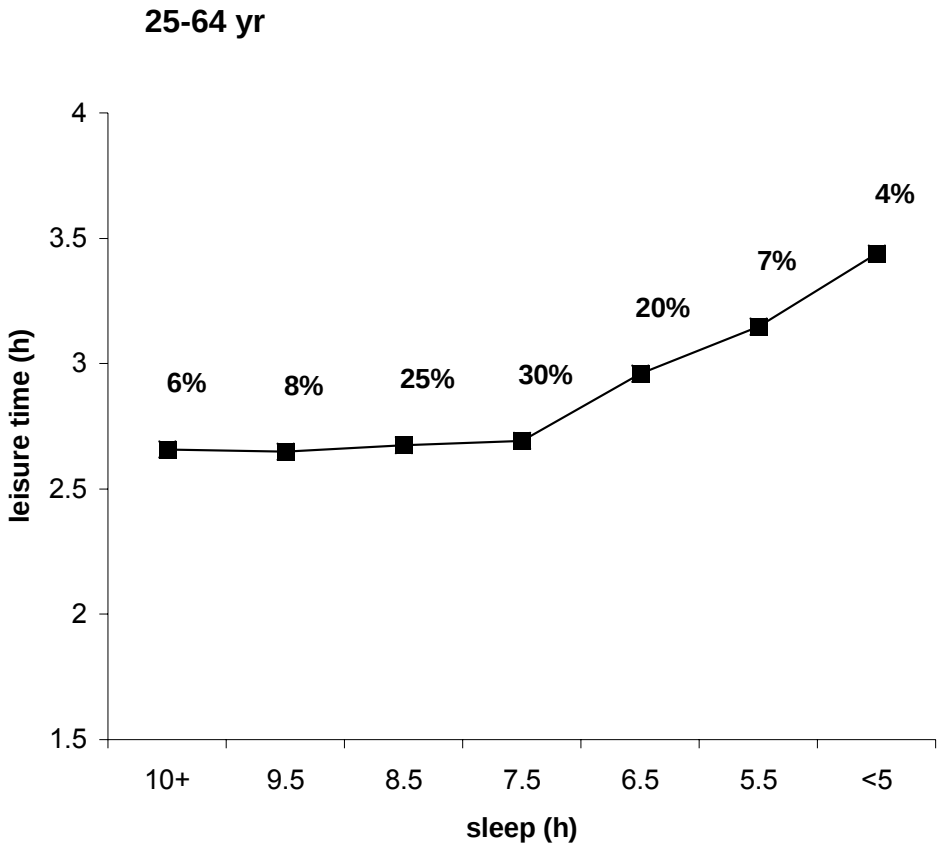

25-64 yr
4
3.5
3
2.5
2
1.5
leisure time (h)
6%
8%
25%
30%
20%
7%
4%
10+
9.5
8.5
7.5
6.5
5.5
<5
sleep (h)

Figure 13

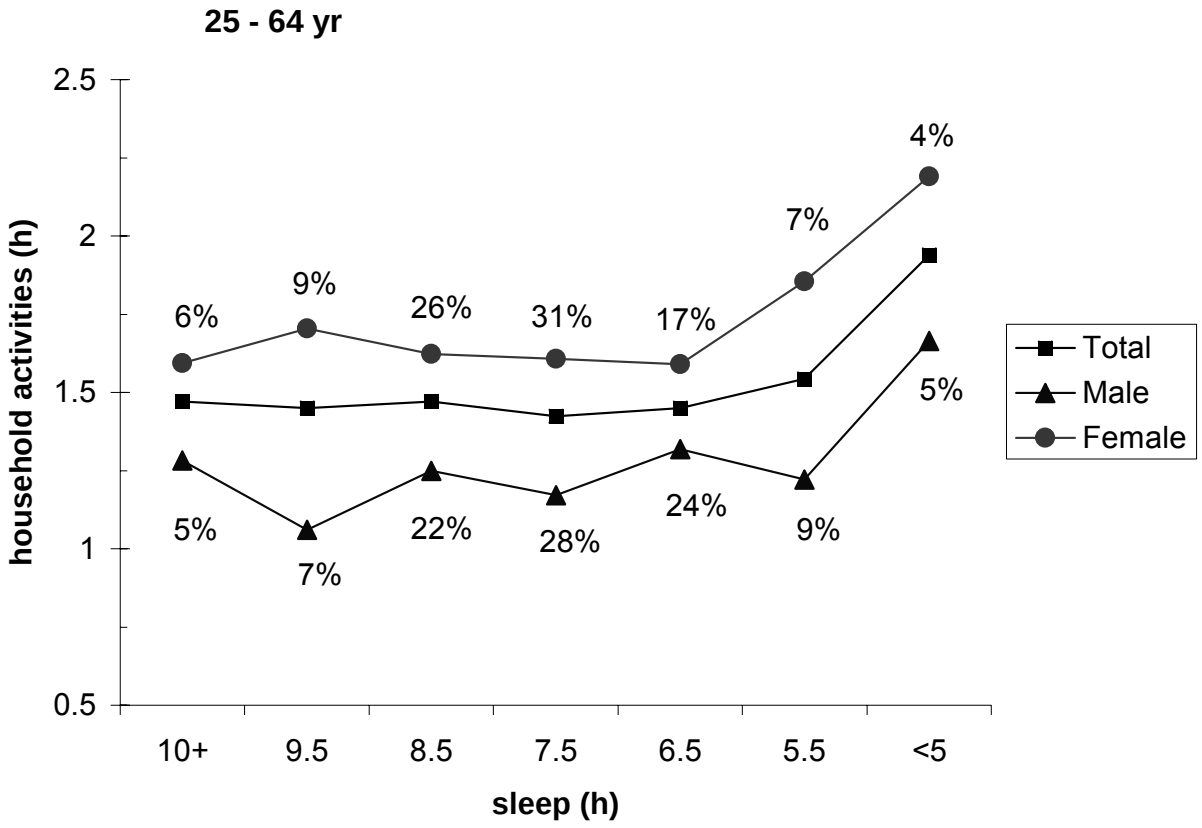
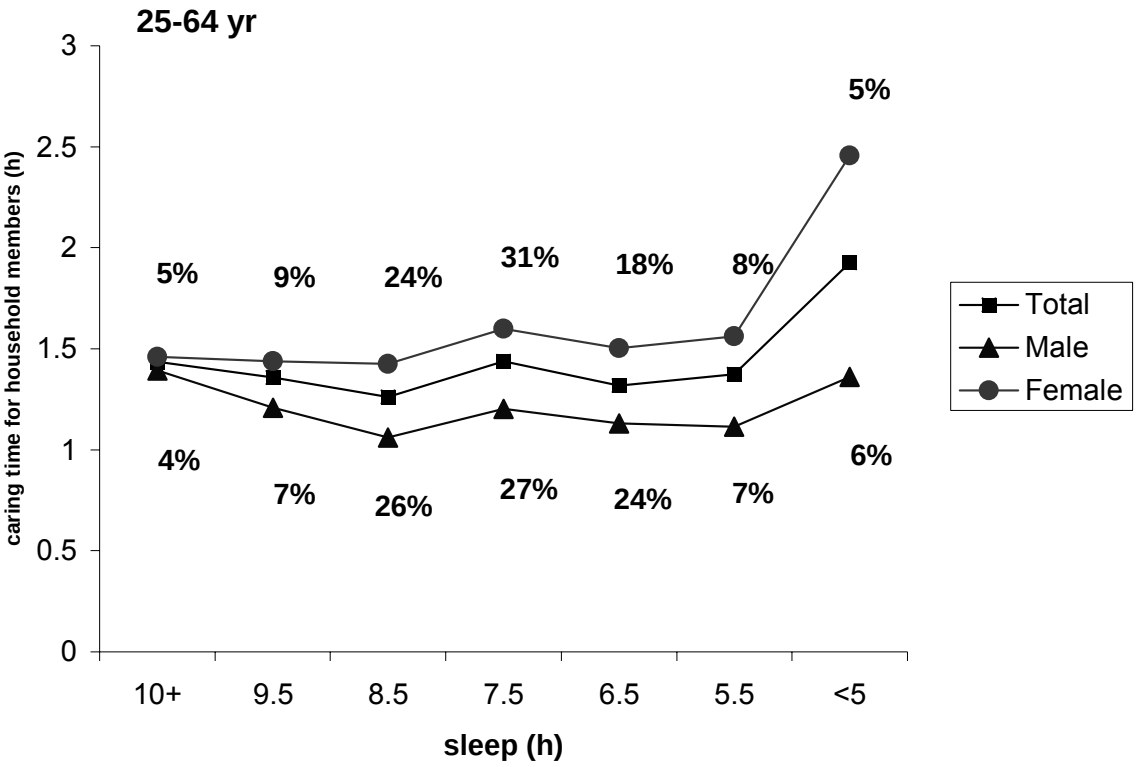

25 - 64 yr
household activities (h)
2.5
2
1.5
1
0.5
10+
9.5
8.5
7.5
6.5
5.5
<5
sleep (h)
6%
9%
26%
31%
17%
7%
4%
5%
7%
22%
28%
24%
9%
5%
Total
Male
Female

Figure 14


25-64 yr
caring time for household members (h)
3
2.5
2
1.5
1
0.5
0
5%
9%
24%
31%
18%
8%
5%
4%
7%
26%
27%
24%
7%
6%
10+
9.5
8.5
7.5
6.5
5.5
<5
sleep (h)
Total
Male
Female