

# Towards a more comprehensive definition of shift work tolerance

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**Abstract:** The aim of the present study was to define the nature of individual differences in shift work tolerance (SWT). This was investigated by an exploratory factor analysis of scores from a wide range of established instruments designed to measure sleep, sleepiness, fatigue, social functioning, as well as physical and mental health. Data were collected from a representative sample of 1,529 Norwegian nurses engaged in rotating shift work. The analyses yielded two factors that seemed to be especially relevant for SWT, namely “Well-being” and “Physical health”. Both factors were related to several demographic and personality variables. In addition, both factors were related to job satisfaction, social support and negative acts, while Well-being was also related to coping. These results support the construct and concurrent validity of the Well-being and Physical factors of SWT. Our findings represent a step towards answering calls from previous research concerning the establishment of a wider definition of individual differences in SWT.

**Key words:** Shift work tolerance, Well-being, Physical health, Validity, Nurses

## Introduction

Individual differences in shift work tolerance (SWT) have been studied extensively over the last few decades. The concept was introduced by Andlauer and colleagues in 1979<sup>1)</sup> as the ability to adapt to shift work without adverse consequences. These authors assumed that SWT was associated with behavioral and biological dispositions that

were reflected in the absence of problems commonly associated with shift work. The opposite of SWT is shift work intolerance and was summed up by Reinberg and Ashkenazi<sup>2)</sup> in terms of the following symptoms: persisting sleep alterations and fatigue, regular use of sleep medications, changes in behavior such as increased aggression and sensitivity, and digestive problems. These symptoms are most commonly measured by questionnaires. Both the assessment and the conceptualization of SWT can, however, be problematic. In his review, Nachreiner<sup>3)</sup> questioned whether the common definitions of SWT are broad enough and included enough potential problems. Nachreiner claimed

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that SWT reflects “an ill-defined concept that shows a biologically restricted perspective of “tolerance” (p. 39). He further criticizes the lack of inclusion of psychosocial and social problems in the earlier definitions of SWT. Clearly there is a pressing need to better define SWT.

Despite the fact that Nachreiner’s review was published 15 yr ago, no research has managed to clearly define an overall measure of SWT. Several researchers have investigated SWT, but the concept has been defined and measured differently<sup>2, 4–8</sup>). A recent paper investigated factors related to an overall measure of SWT amongst nurses<sup>9</sup>), but the measure used was not validated, and failed to cover all aspects of SWT. The present study extended the range of potential aspects of SWT by including health related quality of life including social problems and mental health, alcohol dependency and sleep disorders as well as the measures used by Saksvik-Lehouillier *et al.*<sup>9</sup>), namely insomnia, fatigue, sleepiness, anxiety and depression. These variables are considered relevant for examining the factor structure, construct and concurrent validity of SWT because some of them measure elements stated in the definitions of shift work tolerance provided by Andlauer *et al.*<sup>1</sup>) and by Reinberg and Aschkenazi<sup>2</sup>), and because the others assess other elements of SWT and as such broaden the concept which is called for by Nachreiner<sup>3</sup>).

Defining what constitutes SWT is important since there may be individual differences in SWT<sup>3, 10, 11</sup>) that impact on shift workers’ health and work-related variables. There are for example individual differences in the sensitivity to sleep deprivation which may be important for SWT<sup>12</sup>). Further, knowledge about SWT could be used to better adjust the work conditions to the individual shift worker<sup>11</sup>). In the present paper we investigate the factor structure of SWT using scores from a representative sample of Norwegian nurses engaged in rotating shift work, on a number of relevant established instruments. Since no overall model of what constitutes SWT exists, we utilized an exploratory approach. We further examined the construct validity and concurrent validity of our derived SWT factors by investigating how the factors related to measures of demography, personality, coping and occupational variables.

## Subjects and Methods

### Sample

A total of 2,059 nurses who were members of the Norwegian Nurses Association out of 5,400 invited nurses participated in the initial data collection (response rate: 38.1%). The invited nurses were randomly selected from

five different strata based on how long it was since they completed their nursing education. Accordingly, 1,200 nurses from each of the following five strata were invited: 0–0.1 yr since completion of degree, 1.1–3 yr, 3.1–6 yr, 6.1–9 yr and 9.1–12 yr. However 600 questionnaires were returned with unknown address. One year later a further 905 (of 2,741 newly graduated nurses; response rate: 33%) joined the study. Of the total sample 1,529 were engaged in a rotating three shift schedule (day, evening and night work), and comprised the population for the present study. The sample size for each analysis varies as a function of the response rate on the different variables.

Altogether 133 (8.7%) of the nurses were men, and 1,389 (90.8%) were women. Seven did not report their gender. The participants ranged from 21–62 yr of age (mean 31 yr, SD=7.60). Over half of the nurses worked 90% or more of a full time equivalent (801 nurses, 52.4%), and 53 nurses (3.5%) worked less than 50% of a full time equivalent. The participants had worked as a nurse from less than a year to 35 yr (mean 3.9 yr, SD=4.06). In all, 585 (38.3%) reported that they had children living at home, although 59 participants failed to answer this question.

### Procedure

Data were derived from the first wave of a longitudinal study investigating shift work, sleep and health among Norwegian nurses. The cohort was established in 2008. Data was collected in November 2008 to March 2009. To increase the sample size, and especially the number of newly educated nurses in the sample, an extra data collection was performed from November 2009 to May 2010. Questionnaires and a prepaid return envelope were sent to the nurses’ home addresses. Two reminders (one including a questionnaire) were sent to nurses who did not respond to the initial invitation. The nurses were informed that participation was voluntarily. Gift cards worth 500 NOK (about 85 USD) were given to 25 participants through a lottery, as an incentive to participate. Prior to the data collection the study was approved by the Regional Committee for Medical and Health Research Ethics in Western Norway.

### Measures

The questionnaires included questions on demographic variables. We included questions concerning age, sex (1=male; 2=female) and children at home (1=yes, have children at home; 2=no, do not have children at home) as our control variables. We included the scores on 17 different subscales from eight established instruments in order

to investigate the dimensionality of SWT, thus comprising the dependent variables. Validated Norwegian versions of all instruments were utilized in the study. The *Epworth Sleepiness Scale (ESS)*<sup>13</sup> was included to assess chronic subjective sleepiness. The ESS describes eight situations, and the respondents are asked to indicate how likely, on a scale from 0–3, they are to doze off in the given situation (0=no chance of dozing off; 3=high chance of dozing off). We used the *Bergen Insomnia Scale (BIS)* to measure insomnia<sup>14</sup>. This is a six item long scale based on the DSM-IV criteria for insomnia. The respondents indicate how many times per week during the last month they had experienced different insomnia symptoms (0=no days during the course of a week; 7=every day during the course of a week). We included the *SF-12v2® Health Survey (SF-12v2)*, measuring health related quality of life<sup>15</sup>. There are 12 questions that are divided into eight subscales to measure the following domains: Physical Functioning (PF), Role Limitations Due To Physical Health (RP), Bodily Pain (BP), General Health Perceptions (GH), Vitality (VT), Social Functioning (SF), Role Limitations Due To Emotional Problems (RE) and Mental Health (MH). The questions have different response alternatives, and the scores were transformed along a 0–100 scale where high scores are positive, indicating good health. We also included the *Fatigue Questionnaire (FQ)*<sup>16</sup> measuring fatigue with 11 questions answered on a four point scale. The respondents indicate how often they experience different signs of fatigue. After transforming and adding up the fatigue scores, a high score indicate high level of fatigue. The FQ has two sub-scales, physical fatigue comprising seven questions, and mental fatigue, comprising four of the questions. Originally 13 questions are included in the Fatigue Questionnaire, however, only the 11 questions described here are used to measure total physical fatigue and mental fatigue. We used *The Hospital Anxiety and Depression Scale (HADS)*<sup>17</sup>, to measure symptoms of depression and anxiety, in two different subscales; seven questions assessing depression, and seven for anxiety. The responses are scored from 0–3 (0=low anxiety and depression; 3=high level of anxiety and depression). We further used *The Short Form of the Alcohol Use Disorders Identification Test (Audit-C)* to measure alcohol use and misuse<sup>18</sup>. This instrument includes three questions concerning alcohol consumption. A high score indicate high alcohol consumption. Use of sleep medication was assessed by asking the respondents if they had used any of the following three sleep aids during the past year: Sleep medication on prescription, sleep medication without pre-

scription or melatonin. The respondents answered yes/no to these questions. The questions were collapsed into one variable, with scores ranging from 0 (no on all questions) to 3 (yes on all questions). In addition, we used five questions (question 5–9) from *the Global Sleep Assessment Questionnaire (GSAQ)*<sup>19</sup>. This instrument asks questions pertaining to the frequency of symptoms of specific sleep disorders, over the last four weeks. The items included assess symptoms of obstructive sleep apnoea, restless legs syndrome, periodic limb movement and parasomnia. A high score indicate high frequency of symptoms of sleep disorders.

Individual differences and instruments measuring work environment was used as independent variables. For individual differences we assessed hardiness, morningness, languidity and flexibility. Hardiness was assessed with *The Dispositional Resilience (hardiness) Scale-Revised (DRS-15R)*<sup>20, 21</sup> The respondents are asked to answer on a four-point scale, ranging from “not at all true” to “completely true”, how true 15 different statements concerning thoughts and attitudes are for them. High score means a high degree of hardiness. Morningness was measured with the *Diurnal Scale (DS)*<sup>22</sup>. This instrument comprises seven questions concerning sleep habits, sleep and wake time. Four response alternatives with a range from 1–4 are provided for each question with different ratings. A sum score is calculated. In our study a low score indicates morningness and a high score eveningness. Lastly, languidity and flexibility were measured with the *Circadian Type Inventory (CTI)*<sup>23</sup>. Here the respondents answer how often they experience different scenarios concerning their daily sleep, wake and activity habits and preferences on a five-point scale ranging from “almost never” (=1) to “almost always” (=5).

Finally, the questionnaires included work environment instruments measuring job satisfaction, social support, negative acts and coping. Job satisfaction was measured with the *Job Satisfaction Index (JSI)*, including five items with response options on a five point scale from strongly disagree to strongly agree (high score indicating high job satisfaction)<sup>24</sup>. The items are statements concerning the job, e.g. “I find real enjoyment in my work”. Social support was assessed using a Norwegian version of the *Swedish Demand-Control-Support Questionnaire (DCSQ)*, which has satisfactory psychometric properties in a general Norwegian population<sup>25</sup>. The social support dimension of the instrument has six items, with response ratings ranging from 1 (fully agree) to 4 (fully disagree; high score signifying high social support). Negative acts were assessed

with the short version of the Negative acts questionnaire (S-NAQ;<sup>26</sup>). The S-NAQ consists of nine items concerning exposure to bullying at the workplace. The items are expressed as descriptions of situations and the respondents indicate how often on a scale from 1–5, ranging from never to daily, they have experienced the given situations. A high score on this instrument indicate a high exposure to bullying. The last instrument used was the Instrumental Mastery Oriented Coping factor (IMOC) condensed test battery<sup>27</sup>. The IMOC asks questions about how problems are coped with and is scored on a 4 point scale ranging from seldom or never to very often (1=low coping; 4=high coping).

#### *Statistical analyses*

All analyses were performed using SPSS Version 19 (SPSS, Inc., IBM). We performed a factor analysis to explore the factor structure of SWT. Prior to performing the factor analysis the suitability of the data for factor analysis was assessed. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity generated by PAWS were calculated. The KMO was 0.91, exceeding the recommended value of 0.60. In addition, the Bartlett's Test of Sphericity reached significance ( $p < 0.001$ ), which indicates that factor analysis of the data is appropriate. A principal components exploratory factor analysis (PCA-analysis) with orthogonal rotation (no specification of number of factors) was performed. Orthogonal rotation was chosen in order to simplify the factor structure. However, the use of oblimin rotation resulted in an extremely similar factor structure (results not reported). The following overall scales and sub scales were investigated in the PCA analysis: ESS, BIS, FQ subscales Physical fatigue and Mental fatigue, Anxiety (HADS), Depression (HADS), Audit-C summed score, the 8 subscales of the SF-12v2, Sleep Medication and the summed score of the five items included from GSAQ. The factor scores obtained in the PCA were computed using Bartlett's approach<sup>28</sup> and used in the subsequent analyses.

The number of factors to be retained was decided on basis of Kaiser's criterion, investigation of the Scree plots and theoretical evaluation. A Monte Carlo PCA for Parallel Analysis was also performed to confirm the number of factors to be retained. We calculated correlations between the factors that emerged in the PCA analysis and demographic variables, individual difference variables, job satisfaction, negative acts, coping and social support. We then investigated the relationship between the individual difference variables and the two main SWT factors using two sets of

multiple regression analyses. The two SWT variables were the dependent variables, and the demographic variables and individual difference variables were the predictors. Finally, we performed four multiple regression analyses, with job satisfaction, social support, negative acts and coping as the dependent variables respectively to examine the concurrent validity of our obtained SWT factors. Here all the demographic variables, individual difference variables and the SWT factors comprised the independent variables.

## **Results**

Prior to the PCA analysis the correlation matrix between the composite scores on each scale was examined. All, but one variable (Audit-C summed score), had correlation coefficients with some of the other variables of above 0.3, which supports the suitability of the data for factor analysis. All the other requirements concerning the suitability of the data for factor analysis were met. The PCA analysis of the composite scores showed that four factors had eigenvalues above 1. These four factors explained 35.8%, 9.7%, 6.6% and 6.1% of the variance respectively, giving a total variance explained of 58.3%. Orthogonal (varimax) rotation was performed and the results of this analysis are shown in Table 1.

Four different overall SWT factors emerged in the analysis. The eigenvalue for factor 1 was 6,088, for factor 2 the eigenvalue was 1,657, for factor 3 it was 1,129, and, for factor 4 the eigenvalue was 1,036. Factor one seemed, to be a measure of general "well-being" since it comprised a range of scales relating to psychological health (Table 1). The scales in this factor measured for example social functioning, mental health, vitality, insomnia, fatigue, anxiety and depression, all topics seemingly relevant for well-being. Scales measuring physical health loaded strongly on factor 2, with high scores indicating good health and better SWT (called Physical health). Three scales measuring sleep disorders, sleepiness and use of alcohol loaded on factor 3 while only sleep medication loaded on factor 4. The latter two factors were excluded from further analyses since factor 3 seemed to make little theoretical sense, and factor 4 only included one scale (the composite score on the sleep medication questions). Also, the Scree Plot showed a break after the second component. Two variables cross loaded on factors 1 and 2. General health loaded 0.593 on factor 2 and 0.363 on factor 1. Physical fatigue had a loading of  $-0.677$  on factor 1 and  $-0.358$  on factor 2. Since the highest loading of both these factors were so much higher than the lower loading we chose to keep the

**Table 1. Scale loadings for the Principal Components Analysis (after Varimax rotation)**

Item	Factor loadings			
	1	2	3	4
Sum ESS	-0.304		0.536	-0.453
Sum BIS	-0.534			
Physical Functioning (SF-12v2)		0.764		
Role-Physical (SF-12v2)		0.777		
Bodily Pain (SF-12v2)		0.774		
General Health (SF-12v2)	0.363	0.593		
Vitality (SF-12v2)	0.670			
Social Functioning (SF-12v2)	0.667			
Role-Emotional (SF-12v2)	0.741			
Mental Health (SF-12v2)	0.824			
Physical fatigue	-0.677	-0.358		
Mental fatigue	0.596			
HADS Anxiety	-0.734			
HADS Depression	-0.823			
Audit-C			0.717	
Sleep Medication				0.787
GSAQ			0.618	
Eigenvalues	6,088	1,657	1,129	1,036
% of variance explained	35.81%	9.75%	6.64%	6.09%

Loadings lower than 0.3 are not listed.

**Table 2. Means, standard deviations and correlations between the two SWT variables and all other variables examined (N=1,216–1,516)**

	Mean (SD)	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. Well-being	0.02 (0.99)	-												
2. Physical health	0.01 (0.97)	0.01	-											
3. Age	31.09 (7.6)	-0.04	-0.08**	-										
4. Sex		-0.05	-0.02	-0.04	-									
5. Children at home		0.02	0.07*	-0.46**	-0.03	-								
6. Morningness/E	17.55 (3.36)	0.16**	0.11**	0.06*	0.08**	-0.19**	-							
7. Languidity	20.94 (3.55)	-0.30**	-0.16**	-0.18**	0.09**	0.10**	-0.39**	-						
8. Flexibility	12.43 (3.82)	0.11**	0.05	-0.08**	-0.07**	0.14**	-0.28**	-0.14**	-					
9. Hardiness	31.55 (4.55)	0.46**	0.08**	0.04	0.01	-0.05	0.11**	-0.24**	0.14**	-				
10. Job satisfaction	20.22 (3.37)	0.41**	0.13**	0.01	0.03	0.03	0.09**	-0.19**	0.16**	0.38**	-			
11. Negative acts	10.66 (2.34)	-0.28**	-0.14**	0.01	-0.08**	0.08**	-0.17**	0.16**	0.02	-0.17**	-0.34**	-		
12. Coping	3.01 (0.25)	0.35**	0.07*	0.05*	-0.08**	-0.09**	0.07**	-0.21**	0.09**	0.48**	0.25**	-0.15**	-	
13. Social support	0.72 (0.14)	0.27**	0.09**	-0.08**	0.03	0.07*	0.08**	-0.13**	0.12**	0.28**	0.50**	-0.43**	-0.018**	-

\* $p < 0.05$ , \*\*  $p < 0.01$

variables and not rerun the analysis. General health and physical fatigue also seemed to fit better theoretically with the factors they had the highest loading to.

Correlations between all the variables examined, including the factor scores for Well-being and Physical health are shown in Table 2. All the personality variables and job satisfaction, negative acts, coping and social support showed significant correlations with Well-being. With the

exceptions of languidity and negative acts, all of these correlations were positive, and the strongest correlations were for hardiness and job satisfaction (both  $>0.40$ ). Physical health also showed significant correlations with several of the demographic variables, individual difference variables and the work related variables. Overall, however, these latter correlations were smaller than those found for Well-being.



**Table 3. Individual difference variables predicting Well-being and Physical health (N=1,269–1,523)**

Variable	Well-being			Physical health		
	B	seB	$\beta$	B	seB	$\beta$
Step 1						
Age	-0.01	0.00	-0.04	-0.01	0.00	-0.07*
Sex	-0.19	0.10	-0.06*	-0.07	0.10	-0.02
Children at home	0.00	0.07	0.00	0.07	0.06	0.04
Step 2						
Age	-0.01	0.00	-0.08*	-0.01	0.00	-0.08*
Sex	-0.16	0.09	-0.05	-0.04	0.10	-0.01
Children at home	0.05	0.06	0.03	0.10	0.06	0.05
Hardiness	0.09	0.01	0.41**	0.01	0.01	0.04
Morningness	0.02	0.01	0.06*	0.02	0.01	0.09*
Languidity	-0.05	0.01	-0.19**	-0.04	0.01	-0.13**
Flexibility	0.01	0.01	0.03	0.01	0.01	0.04

Well-being:  $R^2$  Step 1 = 0.004;  $\Delta R^2$  Step 2 = 0.26\*\*. Physical health:  $R^2$  Step 1 = 0.008;  $\Delta R^2$  Step 2 = 0.04\*; \* $p < 0.05$ . \*\* $p < 0.01$

The relationships between the demographic and individual difference variables and the SWT variables were investigated in two separate hierarchical regression analyses (Table 3). The full model, explained 26% of the variance in Well-being ( $F=7,1208=61.31, p \leq 0.001$ ) and 4% of the variance in Physical health ( $F=7,1208=8.09, p \leq 0.001$ ). Hardiness was the strongest (positive) significant predictor of Well-being, followed by languidity. Hardiness was unrelated to Physical health, but languidity had a significant relation to Physical health. To a lesser extent Morningness and age, were significantly related to both Well-being and Physical health, albeit in opposite directions.

Finally, we investigated the relationship between the individual difference and demographic variables, including the SWT measures of Well-being and Physical Health, and four potential dependent variables (job satisfaction, social support, negative acts and coping), using hierarchical regression analyses. These explained 24% of the variance in Job Satisfaction ( $F=9,1206=42.84, p \leq 0.001$ ; Table 4) with Well-being and Physical Health having a significant positive, relation to Job Satisfaction. For Social Support, the full model explained 12% of the variance ( $F=9,1206=19.27, p \leq 0.001$ ). Again, Well-being and Physical Health had a significant positive, relation to the dependent variable. With respect to Negative Acts, the full model explained 11% of the variance ( $F=9,1206=19.36, p \leq 0.001$ ) with Well-being and Physical Health being negatively related to Negative Acts. The full model explained 26% of the variance in Coping ( $F=9,1206=48.42, p \leq 0.001$ ). Only Well-being was significantly, and posi-

tively, related to Coping.

## Discussion

The purpose of this study was to examine, by an exploratory factor analysis, the nature of individual differences in SWT. The analyses yielded four factors. Two of these factors seemed to be especially important for SWT, measuring well-being and physical health. Factor 3 seemed to make little theoretical sense, and factor 4 only included sleep medication. Well-being and Physical Health were related to several individual difference measures; especially so in the case of Well-being and hardiness. We examined the concurrent validity of the Well-being and Physical Health factors by investigating their relationship to four work related variables; job satisfaction, social support, negative acts and coping. Well-being and Physical health were related to each of these factors, with the sole exception that Physical health was not related to Coping. In most cases Well-being was a better predictor of the dependent variables than either the individual difference variables or the demographic variables, although hardiness was the best predictor of Social Support and Coping.

Well-being was not only the factor that explained the largest proportions of the total variance; it also had the strongest concurrent validity of the two SWT factors investigated. Several scales and sub-scales had high loadings on this factor, namely: the sub-scales of Vitality, Social Functioning, Role-Emotional and Mental Health from the SF-12v2 (loaded positively), Mental and Physical

**Table 4. Individual difference variables, and SWT predicting Job Satisfaction, Social Support, Negative Acts and Coping (N=1,269–1,523)**

Variable	Job Satisfaction			Social Support			Negative Acts			Coping		
	B	seB	β	B	seB	β	B	seB	β	B	seB	β
Step 1												
Age	0.01	0.01	0.03	-0.00	0.00	0.06	0.02	0.01	0.05	0.00	0.00	0.01
Sex	0.35	0.34	0.03	0.02	0.02	0.03	-0.64	0.24	0.08*	-0.08	0.03	0.09*
Children at home	0.32	0.22	0.05	0.01	0.01	0.04	0.51	0.15	0.11**	-0.05	0.02	0.09*
Step 2												
Age	0.02	0.01	0.05	-0.00	0.01	-0.05	0.01	0.01	0.04	0.00	0.00	-0.01
Sex	0.60	0.30	0.05*	0.03	0.01	0.04	-0.74	0.23	-0.09**	-0.06	0.02	0.07*
Children at home	0.30	0.20	0.04	0.01	0.01	0.05	0.44	0.15	0.09*	-0.04	0.01	-0.09*
Hardiness	0.16	0.02	0.22**	0.01	0.00	0.18**	-0.01	0.02	-0.03	0.02	0.00	0.34**
Morningness	0.04	0.03	0.04	0.00	0.00	0.05	-0.05	0.02	-0.07*	-0.00	0.00	-0.04
Languidity	-0.00	0.03	-0.01	-0.00	0.00	-0.02	0.03	0.02	0.04	-0.00	0.00	-0.06*
Flexibility	0.09	0.02	0.11**	0.00	0.00	0.07*	0.02	0.02	0.03	0.00	0.00	0.01
Well-being	1.00	0.10	0.30**	0.02	0.01	0.17**	-0.59	0.07	-0.25**	0.04	0.01	0.16**
Physical health	0.35	0.09	0.10**	0.01	0.00	0.06*	-0.32	0.07	-0.13**	0.01	0.01	0.04

Job Satisfaction: R<sup>2</sup> Step 1=0.002; ; Δ R<sup>2</sup> Step 2=0.24\*\*; Social Support: R<sup>2</sup> Step 1=0.006\*; ; Δ R<sup>2</sup> Step 2=0.12\*\*; Negative Acts: R<sup>2</sup> Step 1=0.02\*\*; ; Δ R<sup>2</sup> Step 2=0.11\*; Coping: R<sup>2</sup> Step 1=0.02\*\*; ; Δ R<sup>2</sup> Step 2=0.25\*\*; \*p<0.05. \*\* p<0.01

Fatigue, the HADS questionnaires and the BIS (loaded negatively). The scales important in Well-being seem to be prominent in the definition of SWT provided by Reinberg and Ashkenazi<sup>2)</sup>. This definition focused on (i) sleep deprivation, which was represented in the Well-being variable with the BIS, (ii) fatigue, which is represented by the FQ, and (iii) changes in behavior as increased aggression and sensitivity, which may be tapped by the HADS questionnaire, as the HADS measure mood, nervousness, worrying and ability to relax. The consistency between our findings and previous definitions of SWT supports the construct validity of the Well-being measure. However, Reinberg and Ashkenazi<sup>2)</sup> claim that the use of sleep medication and digestive troubles are central to SWT. Sleep medication did not load highly on Well-being in our study. Rather, the use of sleep medication appeared to be a separate factor. This may reflect on the manner in which sleep medication variable was measured, or it may be that the use of sleep medication is not as paramount in SWT as previously assumed. Also, many of the nurses in our study did not have much work experience as a nurse. The mean number of years of working as a nurse in our sample was about 4 yr. Hence, they may not experience so many troubles caused by shift work and, thus, feel no to take sleep medications, making this variable less relevant in our sample. Still, previous research emphasize that it is especially the first year of shift work that is problematic for many nurses<sup>29)</sup>. Unfortunately we did not measure digestive troubles directly in the present study. However, scales relating to physical

functioning and pain loaded higher on Physical health than Well-being, indicating that such problems may comprise a different aspect of SWT.

Nachreiner<sup>3)</sup> called for a wider definition of SWT and our Well-being factor included variables that are not mentioned in previous definitions. Specifically, the subscales social, emotional and mental health from SF-12v2 which loaded highly on our Well-being factor may be important. Nachreiner<sup>3)</sup> also advocated including social factors that have often been ignored in previous conceptualizations on SWT. The inclusion of the social, as well as the emotional and mental health subscales from the SF-12v2 represents a move in this direction. However, perhaps other scales should have been included as well, as for example scales measuring work-family conflict.

In the present study we examined the concurrent validity of our SWT concepts by examining the SWT factors' relationships with job satisfaction, social support, negative acts and coping. It could equally be argued that these topics are key components of SWT, and therefore should have been included in our factor analysis of what comprises SWT. However, the measures we included were more in line with the previous SWT definitions of Andlauer *et al.*<sup>1)</sup> and Reinberg and Ashkenazi<sup>2)</sup>. Also, our measures comprise several possible consequences of SWT, such as fatigue, sleepiness, anxiety, depression, and mental health, which are central to one of the first operationalizations of SWT made by Andlauer and colleagues in 1979<sup>1)</sup>.

### *Strengths and limitations*

The main strengths of our study are that it included a large number of participants and a wide range of established measures of key elements of SWT. However, our investigation of what determines SWT took advantage of a study in which a wide range of scales had been included, but, not all suggested aspects of SWT, as for example gastrointestinal problems, were included. Another strength is that the participants were selected randomly and although the response rate was rather low (33–38%), this level is both common and acceptable in organizational research<sup>30, 31</sup>. Our sample was comprised of mainly female nurses engaged in rotating shift work and it is questionable as to whether our results could be generalized to other populations. Another limitation is that we used a sample of current shift workers. Ideally shift work tolerance should be examined before entering shift work as well as during shift work<sup>2</sup> in order to minimize selection bias. Also, more than half of the nurses worked >90% of a full time equivalent, and only 3% worked less than 50% of full time equivalent. The amount of work hours per week could have affected the results, however, the distribution working hours of corresponds well with what is normal for nurses in Norway. Some of the nurses included in the study had worked as a nurse for less than a year, and this begs the question as to whether the factors involved in short-term tolerance to shiftwork are the same as those involved in longer term tolerance. Given our sample size we were unable to explore this question but it would clearly be of interest to do so in future research.

Our study was cross-sectional. Consequently, we were unable to examine the predictive validity of our SWT measures. A longitudinal study that used a different method than questionnaires to avoid common method problems would be beneficial. Although the construct validity of our SWT measures was supported by similarities in our findings and previous definitions of SWT, one could question whether our Well-being factor really measures SWT. Our two SWT factors may just reflect some general vulnerability of psychological and physical health problems, and not an ability to adapt to shift work directly. We did not examine the SWT measure among day workers, although the health problems investigated may also be common for work tolerance in daytime workers.

As an overall theory of SWT does not exist, we used an empirical instead of a theoretical approach to the factor analysis of the SWT variables. Thus a weakness of the study is that there is a risk of the measure being skewed in a specific direction based on the number of items reflect-

ing different aspects. Moreover, the empirical approach implicitly assumes that SWT can be measured with a reflexive scale, implying items that interrelate. However, one cannot say for sure that SWT comprise symptoms that correlate.

### *Conclusion*

The present study identified two main factors that seem to be important in SWT. The first factor (Well-being) included measures of insomnia, mental health and well-being, fatigue and anxiety. The second factor included physical health scales. There was an agreement between our findings as to what comprises Well-being and the previous definitions of SWT, although our study suggests that sleep medication should be viewed separately from SWT. Well-being and Physical health were related to job satisfaction, social support and negative acts, while Well-being was also related to coping, supporting the concurrent validity of our SWT factors. Our study is a step towards answering Nachreiner's<sup>3</sup> call for a wider definition of SWT and establishing an overall model of SWT, although more research is needed to further establish the content of our SWT factors. A new definition of shift work tolerance, should, according to our results, not only include insomnia, fatigue, anxiety and depression, but also mental health and social functioning variables.

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