0031-3998/05/5804-0761
PEDIATRIC RESEARCH
Vol. 58, No. 4, 2005
Printed in U.S.A.

Actigraphy Correctly Predicts Sleep Behavior in Infants Who Are Younger than Six Months, When Compared with Polysomnography

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ABSTRACT

Actigraphy has been widely used in adults and children. In infants, validation of actigraphy has typically used a comparison with behaviorally determined sleep state classification rather than polysomnography (PSG). This study validated actigraphy against PSG for determining sleep and waking states in infants who were younger than 6 mo. Twenty-two healthy infants, 13 term and 9 preterm, were studied at three different matched postconceptional ages. Actigraph data were compared with PSG recordings in 1-min epochs. Agreement rate (AR), predictive value for sleep, predictive value for wake, sensitivity. and specificity were calculated and compared between activity thresholds and across ages with two-way ANOVA for repeated measures. Thirty-two validation studies were analyzed. Overall AR with PSG of 93.7 ± 1.3 and 91.6 ± 1.8 were obtained at 2–4 wk and 5–6 mo, respectively, at the low activity threshold setting, whereas the auto activity threshold gave the best agreement with PSG at 2–4 mo (AR 89.3 ± 1.3%). Sensitivity values of 96.2 ± 1.1% at 2–4 wk, 91.2 ± 1.5% at 2–4 mo, and 94.0 ± 1.9% were obtained at these same settings. There was no difference across ages in AR or sensitivity. PVW and specificity values were low in this study. We conclude that actigraphy is a valid method for monitoring sleep in infants who are younger than 6 mo. **(*Pediatr Res* 58: 761–765, 2005)**

Abbreviations

AR, agreement rate
PSG, polysomnography
PT, preterm infants
PVS, predictive value for sleep
PVW, predictive value for wake
T, term infants

Newborn infants spend ~70% of their time asleep, and maturation of sleep is one of the major developments that occur during the first year of life. Sleep-related problems are extremely common in the preschool years, affecting ~30% of this age group (1). Indeed, sleep problems are the most common subject on which parents seek advice from health professionals in these preschool years. These problems can range from disrupted sleep patterns with frequent night awakenings to sleep deprivation. The long-term consequences of poor sleep patterns are known to be slow growth, behavioral problems, poor school performance, family disruption, and even child abuse (2). Most home-based studies on infant sleep patterns have relied in parental reports. However, studies that have used both subjective and objective measures have identified that parental reporting may underestimate night-time awakening (3). Actigraphy provides a useful tool that has advantages over other methods of sleep/wake assessment in that it provides a noninvasive, continuous assessment that can be used for prolonged periods of time in a variety of situations. The actigraph continuously records the occurrence of limb movements and then sums the number of movements for a given epoch length. Through the use of a specially developed algorithm, the motility levels can be computer scored into states of sleep or wake (4,5). The actigraph was first developed for use in adults; however, it has recently been used in children to distinguish between sleep and wakefulness and provides a reliable measure of sleep-wake organization and sleep quality (4). To date, only two studies have been conducted in infants to validate actigraphy against other indicators of sleep state (6,7). Both of these studies compared behaviorally scored sleep and wake with actigraphy. The former study, using a Motion Logger Actiwatch (Model 20000; Ambulatory Monitoring Inc.), found an overall agreement that reached 95.3% for infants aged newborn and 3 and 6 mo, with the lowest correlation in the newborn group (88.9%) (6). The second study found lower agreements

Received September 30, 2004. accepted January 28, 2005.
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This project was supported by grants from the Bonnie Babes Foundation, Ramaciotti Foundations for Biomedical Research, Karitane and SIDassist.

DOI: 10.1203/01.PDR.0000180568.97221.56

Table 1. *PSG and actigraphic predictive sleep/wake states for one subject*

		PSG	
	Sleep	Wakefulness	Total
Actigraphic prediction of sleep	117	7	124
Actigraphic prediction of wakefulness	36	17	53
Total	153	24	177

Predictive value for sleep (PVS) = 100 × 117/124 = 94.3%
Predictive value for wakefulness (PVW) = 100 × 17/53 = 32%
Sensitivity of actigraphy to sleep = 100 × 117/153 = 76.5%
Specificity of actigraphy to wakefulness = 100 × 17/24 = 70.8%
Agreement rate = 100 × (117 + 17)/177 = 75.7%

of between 72 and 95% using a different device (model Z80-32k V_1; Gaehwiler Electronics), with the lowest agreement being in 1-mo-old infants (7). The aims of the current study were to compare actigraphy (Actiwatch AW64; Mini Mitter Company Inc., Sunriver, OR) with polysomnographic determination of sleep and wake in infants up to 6 mo of age and to establish which activity threshold setting was most appropriate for use at each age range.

METHODS

The Monash Medical Centre Human Ethics Committee granted ethical approval for this project. All subjects were volunteers recruited from the maternity wards and Jessie MacPherson Private Hospital, Monash Medical Centre, Melbourne. Written informed consent was obtained from parents before commencement of the study, and no monetary incentive was provided for participation.

Subjects. The study population consisted of 13 (four male, nine female) healthy term infants and nine (four male, five female) preterm infants. The term infants (T) were born at 38–42 wk with birth weights of 2890–4600 g (mean 3625 ± 145 g) and Apgar scores of 9–10 (median 9) at 5 min. The preterm infants (PT) were born at 30–34 wk gestation (mean 32.6 ± 0.5 wk) with birth weights of 1474–2340 g (mean 1918 ± 98 g) and Apgar scores of 7–10 (median 9) at 5 min. Infants were studied at three different matched postconceptional ages: 2–4 wk (n = 8; five PT/three T; one male, seven female; mean 21 ± 2 d), 2–3 mo (n = 13; six PT/seven T; seven male, six female; mean 84 ± 4 d), and 5–6 mo (n = 11; five PT/six T; three male, eight female; mean 171 ± 3 d). Fourteen infants were studied on one occasion only, six infants were studied at two postnatal ages (one at 2–4 wk and 2–4 mo and five at 2–4 mo and 5–6 mo), and two infants were studied at all three ages.

Recording methods. Polysomnographic studies were carried out in the Melbourne Children's Sleep Unit, Monash Medical Centre. Electrodes for recording physiologic variables were attached to each infant during feeding, and, when drowsy, the infant was placed supine in a bassinet under dim lighting and constant room temperature (22–23°C). Using a polygraph (Grass Instrument Company, Quincey, MA), we recorded EEG (C_3–A_2 and O_1–A_2), electrooculogram, submental electromyogram, and ECG; we also measured instantaneous heart rate, thoracic and abdominal breathing movements (Resp-ez Piezo-electric sensor; EPM Systems, Midlothian, VA), blood oxygen saturation (Biox 3700e Pulse Oximeter; Ohmeda, Louisville, CO), and abdominal skin temperature (Yellow Springs Instruments, Yellow Springs, OH). Sleep state was assessed as quiet sleep, active sleep, or indeterminate sleep using EEG, behavioral, heart rate, and breathing pattern criteria (8).

An actigraph (Actiwatch AW64) was placed in a custom-designed sleeve bandage and positioned on the infant's right leg at the midpoint between the knee and the ankle. The Actiwatch weighed 16 g, was sensitive to 0.01 g, sampled at a rate of 32 Hz, and had a nonvolatile memory of 64 KB. Before the placement of the Actiwatch, the time on the Actiwatch was synchronized to the time on the polygraphic trace.

The majority of infants were studied during daytime nap studies between 1000 and 1500 h, with six studies being carried out overnight between 2000 and 0600 h (four at 2–4 mo and two at 5–6 mo). Infant sleep diaries were completed by the parents for the 2 d preceding each study to ensure that the sleep obtained in the laboratory was similar to typical sleep patterns in the home.

Data analysis. Analysis of polysomnography (PSG) records was carried out blinded to the knowledge of actigraphy data. Data from the Actiwatch were coded into sleep and wake in 1-min epochs using commercially available software (Actiware-Sleep V3.3). Data were analyzed at each of the low, medium, high, and automatic activity threshold settings, in which the threshold activity values for low = 80, medium = 40, high = 20, and auto = mean score in active period × 0.888/epoch length. Sleep was scored when total activity counts were less than or equal to the activity threshold setting. For analysis, both PSG and Actiwatch data were reduced to binary form (0 = wakefulness and 1 = any sleep state). Data were analyzed with cross-tabulation using SPSS (Version 11.0.0; SPSS Inc., Chicago, IL) and the agreement rate (AR), predictive value of sleep (PVS), and predictive value of wake (PVW) were calculated as illustrated in Table 1. AR was defined as the proportion of observations for which PSG ratings accorded with Actigraph ratings for both sleep and awake; PVS was calculated as the probability that the Actiwatch prediction was correct by PSG criteria for sleep; and PVW as the probability that the Actiwatch prediction was correct by PSG criteria for wake. We also calculated sensitivity, the ability of the Actiwatch to predict true sleep (number of epochs that the Actiwatch correctly scored as sleep/total number of sleep epochs as scored by PSG) and specificity (number of epochs that the Actiwatch scored correctly as awake/total number of epochs of awake as scored by PSG). Data were compared between each study and each Actiwatch activity threshold level with two-way ANOVA for repeated measures (Sigma Chemical Co. Stat, SPSS Inc.). Agreement rates were also compared between Actiwatches during the same study in five infants. Data are presented as mean ± SEM, with significance at the $p < 0.05$ level.

RESULTS

Thirty-two validation studies with a total of 8342 min were analyzed. With the use of PSG, 6546 min were scored as sleep and 460 min as awake, with 1336 min being excluded because of external movements, such as rocking the bassinet or patting or feeding the infant. Numbers of minutes recorded at each study are detailed in Table 2. There was no significant difference in either the daytime or nighttime sleep duration in the laboratory when compared with the infants' typical sleeping patterns at home (parental sleep diaries) at any age. ARs, PVS, PVW, sensitivity, and specificity for each study and each Actiwatch activity threshold are presented in Table 3.

Agreement rates with PSG. AR ranged from 70.4 to 93.7%, with the high activity threshold consistently recording the lowest values at each study age. The medium activity threshold consistently recorded the second lowest values at each study age. The low activity threshold recorded the highest values of AR at 2–4 wk and 5–6 mo, and the auto activity threshold recorded the highest values at 2–3 mo. At 2–4 wk, the high activity threshold gave significantly lower agreement rates compared with the low ($p < 0.01$), medium ($p < 0.05$), and

Table 2. *Number of minutes recorded using polysomnography at each study*

	Study 1 (2–4 weeks)	Study 2 (2–3 months)	Study 3 (5–6 months)	Total
No studies	8	13	11	32
Total time recorded (min)	1768	4220	2354	8342
Total Sleep (min)	1334	3241	1971	6546
Total Wake (min)	71	292	97	460
Total Epochs Excluded (min)	363	687	286	1336

Table 3. *Summary of data relating actigraphy to PSG: agreement rate (AR), predictive value of sleep (PVS) sensitivity, predictive value for wake (PVW) and specificity, for the three age groups studied and for each activity threshold. All values expressed as mean ± SE*

Activity Threshold	AR (%)	PVS (%)	Sensitivity (%)	PVW (%)	Specificity (%)
2–4 weeks n = 8					
Low	93.7 ± 1.3**	97.2 ± 1.2	96.2 ± 1.1**	33.5 ± 8.4	54.6 ± 13.4
Medium	88.5 ± 3.1*	97.6 ± 1.0	90.1 ± 3.1*	25.8 ± 8.8	62.9 ± 11.2
High	80.4 ± 4.7	98.5 ± 0.8	80.6 ± 4.9	17.0 ± 6.7	82.6 ± 8.4
Auto	91.3 ± 1.5*	96.8 ± 1.0	93.6 ± 1.6**	32.2 ± 10.9	55.9 ± 11.4
2–3 months n = 13					
Low	87.3 ± 1.6¶††	96.9 ± 0.7	88.6 ± 1.8¶††	38.3 ± 6.4	76.3 ± 4.8
Medium	79.6 ± 2.2**	98.3 ± 0.4	78.6 ± 2.5**	27.9 ± 4.9	87.6 ± 3.2
High	70.4 ± 2.7	98.9 ± 0.3	67.6 ± 3.2	21.7 ± 4.1	93.4 ± 2.3
Auto	89.3 ± 1.3¶††	96.2 ± 1.0*	91.2 ± 1.5¶§	43.6 ± 7.1	69.9 ± 5.6
5–6 months n = 11					
Low	91.6 ± 1.8**	97.1 ± 0.8	94.0 ± 1.9¶	37.1 ± 12.4	38.5 ± 13.9
Medium	86.5 ± 2.5*	97.9 ± 0.8	87.5 ± 2.9*	29.2 ± 9.4	63.5 ± 12.5
High	79.6 ± 3.3	98.2 ± 2.2	79.8 ± 3.8	22.6 ± 8.7	61.7 ± 27.5
Auto	90.9 ± 1.6**	96.5 ± 0.8	93.9 ± 1.9¶	41.8 ± 13.8	30.7 ± 10.6*†

* $p < 0.05$ ** $p < 0.01$ ¶ $p < 0.001$ compared with high activity threshold
† $p < 0.05$ †† $p < 0.01$ § $p < .001$ compared with medium activity threshold

auto activity thresholds ($p < 0.05$). At 2–3 mo, the high activity threshold also gave significantly lower AR than the low ($p < 0.001$), medium ($p < 0.01$), and auto activity thresholds ($p < 0.001$). The medium activity threshold also gave significantly lower AR than the low ($p < 0.01$) and auto activity thresholds ($p < 0.01$). At 5–6 mo, the high activity threshold gave significantly lower AR compared with the medium ($p < 0.05$), auto ($p < 0.01$), and low activity thresholds ($p < 0.01$). There was no difference in AR across age at the low or auto activity thresholds; however, on the medium and high activity thresholds, there was a difference between 2–4 wk and 2–3 mo ($p < 0.05$) and between 2–3 and 5–6 mo ($p < 0.05$ and 0.01, respectively).

PVS and sensitivity. The mean PVS values across the three studies and for all four Actiwatch activity thresholds all were high, ranging from 96.5 to 98.9%. There was no difference in PVS values between activity threshold settings at 2–4 wk or 5–6 mo; at 2–3 mo, there was a difference only between the high and auto activity thresholds ($p < 0.05$). There was no difference between studies for any of the four activity threshold settings.

The sensitivity was also high and ranged from 67.6 to 96.2%. As with AR, the high activity threshold setting gave the lowest values of sensitivity and the medium activity threshold the second lowest values across all three studies. The low activity threshold recorded the highest values of sensitivity at 2–4 wk and 5–6 mo and the auto activity threshold setting at 2–3 mo. At 2–4 wk, the high activity threshold gave significantly lower sensitivities than the low ($p < 0.01$), medium ($p < 0.05$). and auto activity thresholds ($p < 0.01$). At 2–3 mo, the high activity threshold also gave significantly lower sensitivity values compared with the low ($p < 0.001$), medium ($p < 0.01$), and auto activity threshold settings ($p < 0.001$). The medium activity threshold also gave significantly lower sensitivity values than the low ($p < 0.01$) and auto activity threshold settings ($p < 0.001$). At 5–6 mo, the high activity threshold gave significantly lower sensitivity values compared with the low ($p < 0.001$), medium ($p < 0.05$), and auto ($p < 0.001$) activity threshold settings. There was no difference in sensitivity across age at the low and auto activity thresholds; however, on the medium and high activity thresholds, there was a difference between 2–4 wk and 2–3 mo ($p < 0.01$) and between 2–3 and 5–6 mo ($p < 0.01$ and $p < 0.001$, respectively).

PVW and specificity. PVWs all were low, ranging from 17.0 to 43.6%. There was no difference between PVW values between activity thresholds at any age or across age. The specificity ranged from 38.5 to 93.4% and reflected the low PVW values. Specificity values were not different between activity thresholds at 2–4 wk or 2–3 mo; however, at 5–6 mo, the auto activity threshold gave significantly higher specificity values than the medium ($p < 0.05$) and high ($p < 0.05$) activity threshold settings. There was no difference in specificity across age at the medium activity threshold; however, on the low, high, and auto activity thresholds, specificity was higher at 2–3 mo than at 5–6 mo ($p < 0.01$).

Determination of the most appropriate threshold setting for actigraphic analysis was based on the best overall agreement rate between actigraphy and PSG (AR) and the highest sleep-predictive (PVS) and sleep-sensitivity actigraphic results. Thus, in this study, we concluded that the low activity threshold setting gave the best results for infants aged 2–4 wk and 5–6 mo, and the auto activity threshold setting gave the best results for infants aged 2–3 mo.

Agreement rates for the activity recorded by two Actiwatches that were worn simultaneously are presented in Table 4. The overall mean ARs in the five studies all were >92% for the individual activity threshold settings.

DISCUSSION

Our study has demonstrated that actigraphy using the Actiwatch AW64 is a reliable method for determining sleep in infants who are younger than 6 mo when compared against PSG. Overall, we found agreement rates of 89–94% between actigraphy and PSG, with the predictive value for determining sleep (PVS) being 97% and sensitivity being between 91 and 96%. However, the Actiwatch was not reliable for determining

Table 4. *Agreement rates between two actiwatches worn simultaneously at low, medium high and auto activity threshold settings (n = 5)*

	low	medium	high	auto
baby 1	88.8	87.1	83.6	90.5
baby 2	88.8	93.1	91.4	94.0
baby 3	94.0	95.7	94.8	96.6
baby 4	96.6	98.3	97.4	97.4
baby 5	98.3	97.4	94.0	97.4
mean	93.3 ± 2.0	94.3 ± 2.0	92.3 ± 2.4	95.2 ± 1.3

wakefulness, with low values for PVW and specificity. Contributing to this finding could have been the relatively low number of epochs of awake that were recorded during the study (460 min awake compared with 6546 min asleep).

Several qualifications must be made in relation to this laboratory-based study. The first is the limited amount of awake data recorded. In this study, we selectively removed all data that were confounded by external movements such as rocking of the bassinet or feeding. This was necessary as, in such instances, the Actiwatch could be logging activity caused by external movement, infant movement, or a mixture of both. In most instances of infant rocking or feeding, the infants were falling asleep, and hence the Actiwatch would have (artifactually) scored the epoch as awake whereas the PSG would have (accurately) scored asleep. Second, this was a laboratory-based study, which may have provided an artificial environment for the infants. However, as part of our usual protocol, parents recorded infant sleep patterns at home before each study, and these did not differ from the time spent asleep in the laboratory; we previously reported this finding in a number of studies (9,10). Third, we compared sleep epochs of 1-min duration in contrast to the usual practice of scoring sleep in 30-s epochs. This longer period was chosen to be able to compare our data with previous studies in infants (3,4,6,7). Fourth, our studies were carried out during the day and overnight. Previous literature has recommended prolonged periods of recording (>3 d) for actigraphic assessment of circadian sleep/wake patterns (4). However, this study aimed to compare minute-by-minute epochs of sleep and wake as scored simultaneously by actigraphy and PSG. Our time frame for data collection thus was similar to that reported in other comparative studies in infants that also used nap periods of 2–2.5 h duration (6) and 3 h (7); in addition, we recorded similar total amounts of sleep. Such study designs, in combination with the necessary exclusion of epochs confounded by movement artifact, yield disproportionate amounts of sleep and awake activity; this requires consideration in future studies that aim to determine the usefulness of the use of actigraphy for determining sleep–wake activity of young infants in the home.

Previous studies have validated actigraphy with relation to behavioral scoring of sleep/wake state in infants with AR of between 72 and 95% (6,7). This current study was the first to use PSG, the accepted gold standard for sleep state determination, to validate actigraphy in infants at three different age groups under 6 mo of age. In a review conducted by Sadeh *et al.* (4), it was noted that agreement rates achieved in the normal adult population when comparing actigraphy with PSG were >90%. In addition, it was found that the total agreement rate achieved when comparing automatic scoring of raw actigraphic activity data against PSG in children aged between 12 and 48 mo was 85.3% (3). However, when the total error was calculated as a percentage of minutes scored as "sleep" over total time in bed, it was found that there was a 5.9% underestimation of sleep with actigraphic scoring compared with polysomnographic scoring (3).

In our study, we investigated the usefulness of actigraphy at three different ages: 2–4 wk, 2–3 mo, and 5–6 mo. Previous studies have shown that actigraphy is less reliable in younger infants with AR of 88.9 (6) and 88.7% (7). We found no difference in AR across age, at the low and auto activity threshold settings. In addition, there was no difference in PVS across age, for any of the activity threshold settings. This is important as sleep problems are most marked in younger infants, and thus a reliable method of determining sleep disruption will be a valuable tool to assess this aspect.

Although actigraphy has been widely evaluated in adults and children, there is a paucity of information regarding its reliability in infants. This deficit in the literature is further complicated by the fact that there are a number of different brands of motion loggers commercially available, each with its own software. It is unclear whether all versions of motion logger hardware and software give equivalent results, and this aspect has been evaluated in only one study in infants (7). In the current study, we used the commercially available algorithms that came with the Actiwatch 64 (Actiware-Sleep V3.3). The sleep-wake algorithms require the researcher to select one of four threshold sensitivity values. If the number of activity counts in a particular epoch falls below threshold sensitivity, then the epoch is scored as sleep. We reasoned that most researchers and clinicians would prefer to use commercially available software; hence, our aim was to evaluate the reliability of this possibility. The Actiwatch was able to determine short periods of spontaneous awakenings during sleep, in addition to periods with larger movements before falling asleep and upon awakening (Fig. 1). Our findings support the conclusions of Sadeh *et al.* (6) that different algorithms for activity need to be used at different ages. We established that the low activity threshold was the most accurate for determining sleep in infants aged 2–3 wk and 5–6 mo and that the auto activity threshold was most appropriate for infants aged 2–3 mo.

Although our study found good agreement between PSG and actigraphy for determining sleep, the PVW between the two measures for determining wake was not as good (17–44%). This finding is in contrast to studies in adults, which found that the agreement rate for the aggregated minutes of wakefulness was 93.5% and that minute-by-minute agreement rates ranged from 88 to 98% (6). The study by Gnidovec *et al.* (7) found low AR at 1 mo (57.5%) and higher values at 3 mo (84.5%) and 6

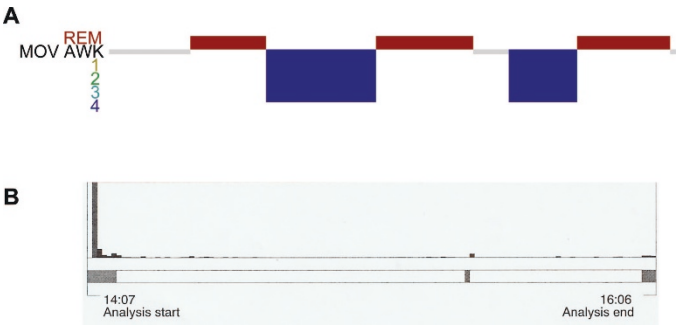

Figure 1. Polysomnographic summary record (*A*) and Actiwatch summary record (*B*) for one infant sleep study at 2–3 mo of age. Note that the polysomnographic record has been scored as only active sleep [rapid eye movement (REM); red bars] and quiet sleep (stages 1, 2, 3, and 4 combined; blue bars) and awake (gray bars). Awake periods at the beginning and the end of the study together with a spontaneous awakening in the middle of the sleep period are scored.

mo (88.4%). Similarly, Sadeh *et al.* (6) found lower AR in newborns (82.8%), relative to older infants at 3 mo of age (AR 92.5%) and 6 mo of age (AR 97.8%). It is relevant that the number of awake epochs that were measured in both of these studies was significantly greater than that measured in this study. Indeed, the highest values of specificity to wakefulness in this study were recorded in the infants who were 2–3 mo of age, when the highest number of epochs of awake was also scored.

It is generally considered that most applications for actigraphy will occur in "natural" sleeping environments (4). On the basis of the results from this study, it is interesting to speculate on the usefulness of predictive values when using actigraphy in home-based investigations of infant sleep development or disturbance, rather than under more controlled and monitored sleep laboratory conditions. After their actigraphy/PSG study in adults, Pollak *et al.* (11) recommended strongly the use of predictive values at the same time as demonstrating that these values varied considerably with the amount of sleep and wakefulness in any given recording period. In their study, for example, actigraphic predictions of wakefulness decreased from 99.5% when recordings were made during "day" (periods spent out of bed with lights on) to 47% when recordings were made during "night" (periods spent in bed with lights off). Such factors will need to be taken into consideration in studies that are home based, and that integrate various aspects of (infant) sleep behavior and physiology.

In five infants, two Actiwatches were used on the same limb to ensure that there was no difference in activity scoring between individual Actiwatches. We found good agreement rates above 92% overall and for the low activity threshold of 93% and auto activity threshold of 95%, indicating that there was little difference between recording devices.

Our study supports the suggestion that actigraphy provides a useful tool for the noninvasive measurement of sleep/wake patterns; however, there are limitations to its use. Actigraphy is unable to differentiate between two categories of wakefulness—crying and noncrying—and also between periods of quiet wakefulness and sleep. Without documentation of sleep and waking provided by sleep diaries, actigraphy is also prone to artifacts such as external motion, thus causing confusion between sleep and wake (5). In the adult population, actigraphy overestimated total sleep time and sleep efficiency in three quarters of the cases, as in this study the ability to detect wakefulness was low, and agreement rates decreased in patients with disturbed sleep (11–13). In addition, Sadeh *et al.* (4) highlighted that automatic algorithms that are indiscriminately applied to unedited raw data could result in the actigraphy's being less reliable as a result of artifacts such as externally induced motion. Despite these limitations, actigraphy is simple to use, is relatively inexpensive, and provides little disruption to normal sleep/wake patterns. Actigraphy thus presents researchers with a useful tool for continuous prolonged recordings of sleep patterns in the natural environment that can also provide information about the subject when he or she is not in bed (3,4).

CONCLUSION

In conclusion, our study has demonstrated that actigraphy can be used as a reliable indicator of sleep in young infants. This validation study may lead to actigraphy's becoming more widely used in clinical and research sleep studies in infants in the future.

Acknowledgments. We thank the staff of the maternity wards, Newborn Services, and Jessie McPherson Private Hospital at Monash Medical Centre and the parents and infants who participated in this study. We also thank Chamali Egodogamage for assistance in data collection.

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