ARMY RESEARCH LABORATORY

Assessment to Determine the Thermal Protective Capability of USMC Modular Sleeping Bag Candidates at -30°F.

Charles A. Hickey, Jr.
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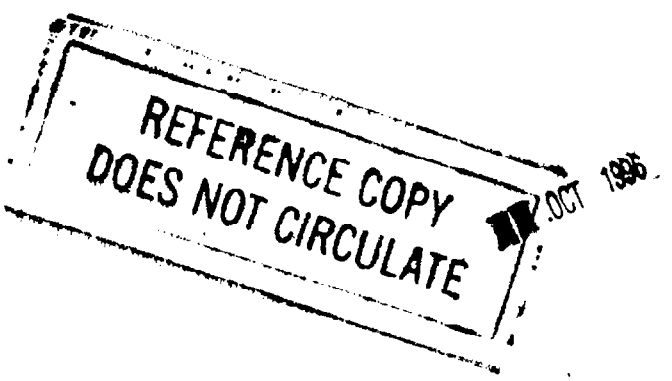

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A preliminary assessment to determine the thermal protective capability of United States Marine Corps (USMC) modular sleeping bag (MSB) candidates was conducted by the Human Research & Engineering Directorate (HRED) of the U.S. Army Research Laboratory, Aberdeen Proving Ground, Maryland, from 23 June through 1 July 1993. The objectives of this assessment were to determine if the candidate MSBs would provide adequate thermal protection to afford users 4 hours' comfortable rest or sleep at -30° F., to determine user comfort and acceptance, and to identify human factors and design shortcomings observed during the assessment. Four marines participated in this assessment. The objective results indicated that none of the MSB candidates provided adequate thermal protection to permit users 4 hours' comfortable rest or sleep. The subjective data indicated that MSB Systems E and F provided the users the most comfort and were most preferred by the marines. Design shortcomings were identified, and suggested design changes were made for each system.

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ASSESSMENT TO DETERMINE THE THERMAL PROTECTIVE CAPABILITY OF USMC MODULAR SLEEPING BAG CANDIDATES AT -30° F.

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ASSESSMENT TO DETERMINE THE THERMAL PROTECTIVE CAPABILITY OF USMC MODULAR SLEEPING BAG CANDIDATES AT -30° F

INTRODUCTION

The United States Marine Corps (USMC) Systems Command (MARCORSYSCOM) prepared a commercial item description and solicited the commercial market place for a modular sleeping bag system. This solicitation called for a two-bag system consisting of a lightweight patrol bag that can be used in temperate climates (+50° to +30° F) and an intermediate cold weather bag that can be used in cold climates (approximately +30° to -10° F). The intermediate cold weather bag fits inside the patrol bag and when used together, is supposed to provide thermal protection to at least -30° F. Nine types of modular sleeping bags were submitted to the USMC from various commercial vendors. MARCORSYSCOM asked the Human Research and Engineering Directorate (HRED) of the U.S. Army Research Laboratory (ARL) to evaluate the thermal protective capabilities of the modular sleeping bag candidates at -30° F. These evaluations were conducted in an environmental chamber in Building 362, Aberdeen Proving Ground, Maryland, from 23 June to 1 July 1993.

OBJECTIVE

The purpose of this evaluation was to determine if the candidate modular sleeping bags would provide adequate thermal protection to afford users 4 hours' comfortable rest or sleep at -30° F, to determine user comfort and acceptance of the sleep systems, and to identify any human factors or design shortcomings observed during this assessment.

SUBJECTS

Four marines (all males) participated in this study. The medical records of these marines were reviewed by U.S. Navy medical officers. These medical reviews assured that none of the subjects had a history of cold intolerance or cold injury, alcoholism, or circulatory disorder. These reviews also assured that none of the subjects were receiving or had recently received medications that would interfere with temperature regulation or shivering. Before the cold chamber evaluation began, these subjects were assembled and given an orientation about the purpose of the test and their participation. After the briefing, the subjects were given volunteer consent affidavits to read. After reading the affidavits, the subjects were given the opportunity to ask and have answered all questions that pertained to the test and their participation. The volunteers were then asked to complete and sign the affidavits (see Appendix A).

The anthropometric measurements of stature and bideltoid (shoulder) breadth were made on these subjects (see Table 1). The design criteria in the commercial item description specified that the modular sleeping bags accommodate marines as tall as 74 inches, who have a bideltoid breadth as great as 21.7 inches, and their cold weather clothing. Percentile values for these measurements were taken from the most recent survey data (1988 Anthropometric Survey of U.S. Army personnel).

Table 1

Anthropometric Measurements of Subjects

Subject No.	Stature		Bideltoid breadth	
	cm	percentile	cm	percentile
1	184.5	91st	45.5	8th
2	179.4	72nd	49.3	54th
3	180.2	75th	50.0	63rd
4	188.0	97th	50.0	63rd

TEST ITEMS

Nine candidate modular sleeping bag systems were evaluated. Each system consisted of two sleeping bags: a lightweight patrol bag and an intermediate cold weather bag. The intermediate bag was designed to fit inside the patrol bag to provide an extreme cold weather sleeping system. Each candidate system was identified only by an alphabetic character (A through I) printed on the bottom section of the foot box of each system. Neither the experimenters nor the subjects knew or could identify the model or manufacturer of any candidate system.

APPARATUS

Clothing and Equipment

The clothing items worn within the modular sleeping bag for each trial consisted of the following:

a. Expedition weight polypropylene undershirt and underdrawers
b. Extended cold weather balaclava (hood)
c. Lightweight polypropylene liner sock.
d. Winter wool sock.

In addition to these clothing items, a long version model of the Therm-a-Rest sleeping pad was placed under each sleeping bag.

Instrumentation

Body temperatures were measured using Yellow Springs Instruments (YSI) Series 400 thermistor sensors hardwired to a computer-controlled Hewlett-Packard data acquisition system configured to read YSI thermistors. The sensors applied to each subject were harnessed and identified so that any given sensor was always used at the same body location on each individual subject for all trials. Body temperatures were measured at the following locations:

a. Rectal temperature, using a rectal thermistor inserted to a depth of 10 cm.

b. Fingertip temperature, using a disc skin sensor mounted on the palmar surface of the tip of the middle finger on the right hand.

c. Toe temperature, using a disc skin sensor mounted on the inside surface of the large toe of the right foot.

d. Back temperature, using a disc skin sensor mounted on the skin of the back medial to and slightly below the center of the right scapula blade.

A complete set of temperatures was recorded for all subjects at 1-minute intervals for the duration of the exposure period for each trial.

Test Facility

An environmental chamber in Building 362, Aberdeen Proving Ground, Maryland, was used for this evaluation. For the duration of this study, the chamber temperature was held to within less than 1° from a mean of -30° F.

PROCEDURES

Each subject arrived at the test facility and received his wiring harness, which included the skin and rectal thermistors he was assigned. The subjects then went to the changing area (rest room), took off their clothing, emplaced their rectal thermistors, and then donned their polypropylene underdrawers. The experimenters then emplaced the skin thermistors on each subject. When completed, the subjects were told to put on the rest of their clothing. While the subjects were dressing, the experimenters placed the sleeping bags onto the sleeping pads in the cold chamber. The sleeping bags and sleeping pads were laid on a thermally isolated wood platform that was placed on the steel floor of the chamber. When the subjects were dressed, they entered the cold chamber and promptly entered the sleeping bags. The experimenters helped each subject to zip the sleeping bag closed and to tighten the drawstrings of the hood on the sleeping bag. The experimenters then connected the sensor leads for the subjects. Each subject remained in his sleeping bag and tried to sleep or at least rest comfortably for the 4-hour exposure period. All body measurements were recorded at 1-minute intervals throughout the exposure period. The experimenters observed the subjects during each exposure period through a window in the chamber door. Once a 4-hour trial began, the experimenters did not enter the chamber unless signaled by a subject or unless they felt the need to check the subjects.

A subject was removed from the chamber if any of the following occurred: (a) any surface skin temperature fell below 50° F; (b) the core or rectal temperature fell to 95° F; (c) a subject experienced involuntary continuous shivering for 5 minutes as reported by the subject and confirmed by the experimenter; or (d) the cold exposure period reached 240 minutes.

After all subjects completed the scenario, they were given a subjective questionnaire to complete. They also were encouraged to write any additional comments. A copy of the questionnaire is shown in Appendix B.

TEST DESIGN

Independent Variables

Candidate modular sleeping bags

Dependent Variables

The dependent variables are as follow:

a. Core (rectal) temperatures

b. Skin sensor temperatures

c. Time that the onset of involuntary shivering occurs

d. Responses to subjective questionnaires

e. Debriefing comments

f. Human factors observations within the scope of study

Test Matrix

The order of presentation is shown in Table 2. Only one of each candidate system was available for this test. This matrix was used to afford a full day for the bag to dry and for any moisture to be eliminated that may have accumulated in the sleeping bags' insulation during a test trial. Note that the matrix does not include Candidate System I. This system failed to meet a sizing criterion (see Results) and therefore was not evaluated in the cold chamber.

Table 2

Test Matrix

Subject No.	Trial No. 1	2	3	4	5	6	7	8
1	G	B	H	C	D	A	F	E
2	H	E	D	A	F	C	G	B
3	D	C	F	B	G	E	H	A
4	F	A	G	E	H	B	D	C

ACCEPTANCE CRITERIA

The following criteria, established by the USMC, were used to determine if the candidate modular sleeping bags provided adequate thermal protection:

1. If three of the four subjects reached thermal steady state (constant body temperature) within the 4-hour exposure period, or if three of the four subjects were able to at least maintain skin temperatures of 60° F or greater

for the entire exposure period, the modular sleeping bag provided adequate thermal protection to afford 4 hours' rest or sleep and was considered acceptable.

2. However, if a subject was unable to establish a thermal steady state or reached one or more of the cutoff limits in less than the 4-hour exposure period, the modular sleeping bag was considered unacceptable.

DATA ANALYSIS

All the temperature data recorded from each subject during a given cold exposure trial were plotted to produce a set of temperature versus time curves on a single graph. These graphs provide the means for deriving estimates of the most important factor used to evaluate thermal protective effectiveness of cold weather clothing and equipment (sleeping bags), namely, the rate of change of temperature at the body locations monitored.

To accomplish this, one must first choose the time interval over which evaluations of temperature rate changes will be made. The moment the subjects enter the chamber, the temperature difference between their body surfaces and the ambient air increases greatly (in this study about 100° F [from the room outside the chamber at +70° F to cold chamber at -30° F]). For subjects lightly dressed and entering a sleeping bag, a substantial amount of time is required to readjust the heat flow gradient between themselves and the bag. Other studies indicate (vanDilla, 1949) that this period of adjustment requires about 60 minutes. In addition, the body surface temperatures are much affected by the conditions and events experienced by the subjects during the period preceding the onset of the low temperature exposure. Therefore, temperature data collected during this initial 60-minute exposure phase should be ignored. The skin temperature data were also used to determine the times required to reach the functional temperature limit of 60° F.

The daily and posttest debriefing comments were summarized, and the mean scores for the five-point rating scale questionnaires were tabulated. After the posttest debriefing, the subjects were instructed to rank order their preferences for a candidate system.

RESULTS AND DISCUSSION

Before the cold chamber evaluation began, a fitting survey was conducted to assure that the modular sleeping bags would accommodate the size of the subjects. As a result of this pretest survey, Candidate Sleep System I was eliminated because of its length. The Marine Corps requirement states that the modular sleeping bags will be constructed with sufficient size to accommodate a 6-foot 2-inch marine with a bideltoid breadth of 21.7 inches and his or her cold weather clothing. Three of the subjects (Numbers 1, 3, and 4) could not lie flat in this bag because it was too short; in fact, with the hood in place, these subjects had to bend their necks forward when the bag was zipped closed. In addition to not being able to lie flat, the subjects pressed against the inner lining of the bag in such a manner that the insulation in the hood and foot box was compressed considerably. This condition would have made the bag uncomfortable to use, and thermal protection would have been sufficiently reduced in the area of the feet, neck, and head. The bag was therefore excluded from the evaluation.

Cold exposure trials at -30° F were conducted to determine if the candidate sleeping systems provide adequate thermal protection to afford users 4 hours' comfortable rest or sleep. Graphs of all the temperature versus time data recorded for each candidate system are shown in Appendix C. Each graph presents the body temperature data for a given subject in a given sleeping system. A skin temperature of 60° F has been established (vanDilla, 1949) as the level of finger temperature at which most young males begin to experience both cold-induced pain and decrements in manual task performance. The experiences of past studies (Hickey, Woodward, & Hanlon, 1992) on cold protective ensembles show that fingers and toes differ very little in these respects. Therefore, 60° F has been taken as a functional temperature limit for fingers and toes during cold weather protective ensemble evaluations. For these reasons, it is felt that users would not be able to sleep or rest comfortably if their feet (or hands) cooled to 60° F or lower. Since the feet (toes) were the only area that cooled enough to cause discomfort to the subjects, only the toe temperature data were used. The remaining temperature data are presented graphically in Appendix C.

The objective data show that none of the candidate modular sleeping bags met the acceptance criteria for service at -30° F. In each case, at least two of the subjects could not maintain skin temperatures (feet) of 60° F or greater. Three of the candidate systems (C, E, and G) were found to be deficient in protection capability because a subject fell below the safety cutoff limits of 50° F for skin temperatures before the end of the 4-hour exposure period. No subjects reached this limit in the remaining candidate systems, but none of the candidate systems enabled three of the four subjects to reach a thermal steady state or skin (toe) temperature of 60° or greater for the entire 4-hour exposure period. Table 3 presents the lowest toe temperatures reached by each subject during the 4-hour exposure period in each sleeping system.

Table 3

Lowest Skin Temperature (toe) Noted During the 4-hour Trial

Sleeping system	Subject No. 1	2	3	4	Mean	SD mean
A	52.1	53.8	81.6	56.7	61.1	6.9
B	54.0	53.2	84.8	73.0	66.3	7.7
C	49.7	56.1	89.5	83.6	69.7	9.9
D	52.2	58.0	62.3	58.2	57.7	2.1
E	49.6	55.0	87.6	87.2	69.9	10.2
F	58.4	56.2	80.5	60.1	63.8	5.6
G	49.6	56.1	85.1	68.3	64.8	7.8
H	57.9	54.1	81.8	63.1	64.2	6.2

Table 4 summarizes the data about functional tolerance times for the feet (toes). In cases when these temperatures did not actually drop to 60° F before the end of the exposure period, the time is shown as 240 minutes, the maximum exposure time. Table 5 is a summary table that shows the subjects' toe temperatures at the end of each trial.

Table 4

Time to Reach Functional Temperature Limit of 60° F
Skin Temperature (toe) in Minutes

Sleeping system	Subject No. 1	2	3	4	Mean time	SD mean
A	172	126	240	145	170.75	24.94
B	109	106	240	240	173.75	38.25
C	111	157	240	240	187.00	32.00
D	140	229	240	125	183.50	29.69
E	126	130	240	240	184.00	32.35
F	225	198	240	240	225.75	9.90
G	83	108	240	240	167.75	42.02
H	208	114	240	240	200.50	29.80

Table 5

Toe Temperatures (degrees F) at the End of the 4-Hour Exposure Period

Sleeping system	Subject No. 1	2	3	4	mean	SD mean
A	52.5	53.9	81.7	57.8	61.5	6.8
B	54.1	53.8	84.8	75.6	67.1	7.8
C	49.8[a]	57.6	92.9	86.3	71.7	10.6
D	52.2	58.0	62.3	77.9	62.6	5.5
E	49.9[b]	55.9	93.7	89.8	72.3	11.3
F	58.6	58.0	85.9	75.4	69.5	6.8
G	49.6[c]	57.4	89.1	71.7	66.9	8.7
H	58.0	54.1	81.9	63.5	64.4	6.2

[a]Subject fell below 50° F after 196 minutes.
[b]Subject fell below 50° F after 219 minutes.
[c]Subject fell below 50° F after 225 minutes.

Subjective data were collected on daily questionnaires to solicit the subjects' opinions about the sleeping systems used during the evaluation. A five-point rating scale questionnaire was given to each subject at the end of every trial. The raw scores were collated and used to compute descriptive statistics for the ratings of each sleeping system. The means and standard deviations for each rating are shown in Table 6. Mean scores greater than 4.0 show that a specific feature was rated favorably. Mean scores below 3.0 indicate that a specific feature was considered somewhat less than acceptable.

The subjects were also asked to answer specific questions and to write any additional comments (favorable or unfavorable) they had about each sleep system. These questions pertained to their ability to remain warm and their

ability to sleep or rest comfortably. In addition, they were asked to describe the location of cold spots that were felt in any area of the sleeping systems. Most responses pertained to the cold spots noted at the zippers and in the foot box of the sleeping bags. There were also unfavorable responses about the size and shape of the hood and the physical size of the sleeping bags. These answers and comments were tabulated for each system and are listed in Appendix D.

After the last trial, the subjects participated in a posttest debriefing session. During the session, the subjects were asked (based on their individual experiences) to rank the sleep systems from most to least preferred. The rankings were to be based on the capability of the systems to provide cold weather protection and to provide sufficient comfort for a user to rest comfortably for 4 hours. The rankings by subject are shown in Table 7.

Table 6

Summary of Responses from the Five-Point Rating Scale Questionnaires

Feature rated		Modular Sleeping System A	B	C	D	E	F	G	H
Quality of rest or sleep	mean	3.5	3.5	3.0	3.3	4.5	3.8	4.3	3.3
	SD	1.3	1.2	1.9	1.0	0.6	1.3	1.0	1.0
Overall comfort	mean	3.3	3.3	4.0	3.8	4.8	4.3	4.3	3.0
	SD	1.5	1.0	2.0	1.0	0.5	1.0	1.0	0.8
Ability to keep warm	mean	2.8	3.0	4.0	3.0	4.5	4.5	3.8	3.3
	SD	1.0	1.2	2.0	1.2	0.6	0.6	1.9	1.5
Room inside bag	mean	3.3	3.0	4.3	4.3	4.8	4.0	4.0	1.8
	SD	1.0	0.8	0.5	0.5	0.5	1.4	1.4	1.5
Ability to change position	mean	3.3	3.3	4.8	4.3	4.5	4.0	4.0	2.0
	SD	1.0	1.0	0.5	0.5	1.0	0.8	1.4	1.4
Length of bag	mean	3.3	4.0	4.3	4.0	4.5	4.3	4.8	2.5
	SD	1.0	0.8	1.0	0.8	0.6	1.5	0.5	1.9
Width of bag	mean	2.8	3.0	4.0	4.3	4.3	4.3	3.8	2.0
	SD	1.3	1.4	0.8	0.5	1.0	1.0	1.3	2.0
Size and shape of hood	mean	3.8	3.5	3.3	3.3	4.5	4.3	4.0	3.3
	SD	1.0	1.0	1.3	1.3	1.0	1.0	1.2	2.1
Hood closure	mean	3.5	3.8	2.8	3.5	4.5	4.3	3.5	3.5
	SD	1.3	1.0	1.5	1.0	1.0	1.0	1.3	1.9
Size and shape of foot box	mean	3.8	3.5	4.8	3.8	4.3	4.3	4.8	2.8
	SD	0.5	0.6	0.5	0.5	1.0	1.0	0.5	1.3
Total ranking		29.5	32.5	47.5	41.0	72.5	62.5	56.5	18.0

Table 7

Rank Order Selection of Systems

Subject	System ranking - most preferred to least preferred							
1	F	D	E	G	A	B	C	H
2	F	E	G	C	H	D	A	B
3	E	F	C	G	B	A	H	D
4	E	C	B	G	F	D	A	H

None of the systems provided thermal protection to afford all subjects 4 hours' comfortable rest or sleep. However, the questionnaire response data and the rank ordering selections for the most preferred systems showed a subjective preference for Systems E and F. The questionnaire data were subjected to a Friedman Test for matched pair groupings. A chi-square, 37.8, df=7, indicated that there were significant differences (.05 α level) between systems. The features or characteristics for Systems E and F were rated significantly better than those of the other systems, especially those pertaining to overall comfort and ability to keep warm. This was also reflected by the rank order preference made by the subjects.

A review of the subjective comments showed that five of the systems (A, B, E, G, and H) evaluated were considered to be too narrow by at least one of the subjects (not always the same subject). They often stated that these bags were restrictive or tight in areas about the shoulders, chest, or knees. A primary concern is that none of these subjects were larger than 50.0 cm (19.7 inches) in bideltoid breadth, which corresponds to the 63rd percentile range for this measurement. The sizing criterion states that these sleeping systems should be sized to accommodate users as tall as 74 inches, who have a bideltoid breadth as great as 21.7 inches. The subjective comments indicate that these systems were too narrow to comfortably accommodate some of the subjects. What is unknown is whether the sleeping bags that were considered too narrow were cut to the 21.7-inch bideltoid breadth criterion or whether bideltoid breadth is an inappropriate measure to use to size a sleeping system. Shoulder circumference may be a better measurement to use for a sizing criterion.

SYSTEM DESIGN CONSIDERATIONS

The final objective was to identify any design shortcomings that were evident in any of the systems. The shortcomings noted during this evaluation were based on experimenter observations and the subjective comments made by the subjects. Because of the limited number of subjects participating in this study, it is difficult to place a value or relative merit on the subjective comments and recommendations. The following is a list of shortcomings and some general recommendations for each sleep system.

System A

1. All subjects stated that they could not remain warm in this system and felt discomfort to some degree because of cold feet. One subject

specifically noted cold spots in the foot box. In addition, all subjects felt cold air seeping through the zipper. It was noted that the insulation in this particular system felt lighter or thinner than others. Additional insulation is required, especially in the area of the foot box and where the bag contacts users' backs. The draft tube should be redesigned so that it prevents cold air from leaking into the bag through the zipper closure.

2. Two subjects stated that the bag was narrow and felt too tight at the shoulders and chest. The width or circumference of the sleeping bag should be increased to provide more room in the shoulder and chest area.

3. All subjects stated that the D-shaped ring and velcro closure at the top of the bag kept the zipper from being inadvertently unzipped. However, this type closure would not permit rapid emergency egress required for military operations. The D-shaped ring should be eliminated and a velcro closure that can be readily unfastened should be used.

System B

1. Three subjects noted that they could not remain warm for the entire exposure period becaue of cold feet and backs. Two of these subjects stated that they could not rest comfortably because their backs and feet were uncomfortably cold. Three subjects specifically noted cold spots where their backs touched the bags and in the foot box. One subject noted cold air seeping through the zipper, and two stated that cold air seeped into the top of the bag where there is a gap between the hood and bag. Additional insulation is required for this system, especially in the area of the foot box. The draft tube should be redesigned to prevent cold air from seeping through zipper into the bag, and the size and shape of the hood should be redesigned to prevent cold air from seeping into the top of the bag.

2. Two subjects noted that this system was narrow and too tight in the shoulders and chest. The width or circumference of the sleeping bag should be increased to provide more room for shoulders and chest.

3. All subjects stated that the D-shaped ring and velcro closure at the top of the bag kept the zipper from being inadvertently unzipped. However, this type closure would not permit rapid emergency egress required for military operations. The D-shaped ring should be eliminated, and a velcro closure that can be readily unfastened should be used.

System C

1. Two subjects noted that cold air seeped into the bag through the zipper, and two noted that the excessive size of the hood permits cold air to seep into the bag. The draft tube should be redesigned to eliminate cold air from seeping through the zipper. The hood should be reshaped and resized so that it closes tightly and seals around the head of the user.

2. All subjects stated that the D-shaped ring and velcro closure at the top of the bag kept the zipper from being inadvertently unzipped. However, this type closure would not permit rapid emergency egress required for military operations. The D-shaped ring should be eliminated, and a velcro closure that can be readily unfastened should be used.

System D

1. Two subjects noted cold spots at the zipper, and another noted a cold spot in the middle of his back. All subjects noted that the draft tube moves away from the zipper when the bag is zipped closed. The draft tube should be redesigned or repositioned so that it does not move away from the zipper when the bag is zipped closed. Additional insulation may be required to eliminate cold spots in area of users' backs.

2. The D-shaped ring and velcro closure at the top of the bag are used to prevent the zipper from being inadvertently unzipped. All subjects stated that this worked so well that it would not permit rapid emergency egress required for military operations. The D-shaped ring should be eliminated, and a velcro closure that can be readily unfastened should be used.

System E

1. Two subjects noted that the zippers did not operate well because the shell material got caught in the zipper. It took considerable effort to unstick the zipper. The thickness and width of zipper stiffener should be increased to prevent the zipper from catching fabric.

2. One subject noted that the bag was narrow and restrictive in the area between the mid thigh and knee. Increasing the width in this area of the bag should be considered.

System F

1. One subject got the inner shell material caught in the innermost zipper. The thickness and width of zipper stiffener should be increased to prevent the zipper from getting caught in material.

2. One subject noted that closure around the hood and top of the bag would not remain snug. The closure should be redesigned so that hood remains snug after adjusting.

System G

1. Two subjects noted cold air seeping through the zipper and another noted that the draft tube moves away from the zipper if a person moves around much in the bag. The draft tube should be redesigned to prevent cold air from seeping through the zipper and into the bag.

2. One subject stated that the middle portion of the bag was narrow and felt restrictive. Increasing the width or circumference in the mid section of the bag should be considered.

3. Two subjects noted that the shape of the hood does not conform to the shape of a person's head. The hood is too flat and is not deep enough to fit properly around the head. These subjects also stated that the opening was excessive between the bottom of the hood opening and top of the bag. The hood should be resized and reshaped to conform to the head.

System H

1. Three subjects noted that this bag was generally too narrow and was very restrictive in the shoulders. They also noted that this bag was somewhat short. All three thought that it was tight enough to compress the insulation. The overall size of this bag should be increased to enhance user comfort and reduce the compressing of insulation.

2. Two subjects noted cold air seeping through the zipper because the draft tube was too narrow to adequately cover the zipper. The draft tube should be redesigned to prevent cold air from seeping through the zipper.

3. Two subjects noted that the size and shape of the hood was inadequate and permitted cold air to enter the bag. The hood should be resized and reshaped to conform to the head.

CONCLUSIONS

1. Based on the acceptance criteria, none of the modular sleeping bag candidates evaluated provided adequate thermal protection to afford users 4 hours' comfortable rest or sleep.

2. Subjective data indicate that Systems E and F provided the user the most comfort and were the systems most preferred by the subjects.

3. System I failed to met the sizing criteria and was therefore not evaluated in the cold chamber.

RECOMMENDATIONS

1. Changes to correct the design shortcomings identified for the modular sleeping bags should be considered.

2. Independent evaluations should be conducted to assure that each component (the lightweight patrol bag and the intermediate cold weather bag) of the modular sleeping bag will provide adequate thermal protection.

3. Additional controlled evaluations should be conducted using larger subject groups (e.g., 8 to 12 subjects) before this sleep system is fielded.

REFERENCES

Hickey, C. A., Woodward, A. A., & Hanlon, W. E. (1992). A pilot study to determine the thermal protective capability of electrically heated clothing and boot inserts (ARL Technical Report No.(in publication), APG, MD.

vanDilla, M. A., et al. (1949). Laboratory and field studies. In L. A. Newburgh (Ed.), Physiology of heat regulation and the science of clothing (Chapter 11). Philadelphia, PA: W. B. Saunders.

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APPENDIX A

VOLUNTEER AGREEMENT AFFIDAVIT

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VOLUNTEER AGREEMENT AFFIDAVIT

For use of this form, see AR 70-25; the proponent agency is OTSG

PRIVACY ACT OF 1974

Authority: 10 USC 3013, 44 USC 3101, and 10 USC 1071-1087.

Principle Purpose: To document voluntary participation in the Clinical Investigation and Research Program. SSN and home address will be used for identification and locating purposes.

Routine Uses: The SSN and home address will be used for identification and locating purposes. Information derived from the study will be used to document the study, implementation of medical programs, adjudication of claims, and for the mandatory reporting of medical conditions as required by law. Information may be furnished to Federal, State and local agencies.

Disclosure: The furnishing of your SSN and home address is mandatory and necessary to provide identification and to contact you if future information indicates that your health may be adversely affected. Failure to provide the information may preclude your voluntary participation in this investigational study.

PART A(1) - VOLUNTEER AFFIDAVIT

Volunteer Subjects in Approved Department of the Army Research Studies

Volunteers under the provisions of AR 40-38 and AR 70-25 are authorized all necessary medical care for injury or disease which is the proximate result of their participation in such studies.

I, _____, SSN _____.

having full capacity to consent and having attained my _____ birthday, do hereby volunteer/give consent as legal representative for _____ to participate in A Prelimary Assessment to Determine the Thermal Protective Capability of USMC Modular Sleeping Bag Candidates at -30°F. (Research study)

under the direction of Mr. William E. Hanlon

conducted at Aberdeen Proving Ground, MD (Name of institution)

The implications of my voluntary participation/consent as legal representative; duration and purpose of the research study; the methods and means by which it is to be conducted; and the inconveniences and hazards that may reasonably be expected have been explained to me by

Mr. William E. Hanlon

I have been given an opportunity to ask questions concerning this investigational study. Any such questions were answered to my full and complete satisfaction. Should any further questions arise concerning my rights/the rights of the person I represent on study-related injury, I may contact

Chief, Patient Administration Branch

at Kirk Army Health Clinic, Aberdeen Proving Ground, MD 21005, (410) 278-2086 (Name, Address and Phone Number of Hospital (Include Area Code))

I understand that I may at any time during the course of this study revoke my consent and withdraw/have the person I represent withdrawn from the study without further penalty or loss of benefits; however, I/the person I represent may be required (military volunteer) or requested (civilian volunteer) to undergo certain examination if, in the opinion of the attending physician, such examinations are necessary for my/the person I represent's health and well-being. My/the person I represent's refusal to participate will involve no penalty or loss of benefits to which I am/the person I represent is otherwise entitled.

_____

PART A (2) - ASSENT VOLUNTEER AFFIDAVIT (MINOR CHILD)

I, _____, SSN _____ having full capacity to consent and having attained my _____ birthday, do hereby volunteer for _____ to participate in _____

_____ (Research Study)

_____

under the direction of _____

conducted at _____ (Name of Institution)

(Continue on Reverse)

PART A(2) - ASSENT VOLUNTEER AFFIDAVIT (MINOR CHILD) (Cont'd)

The implications of my voluntary participation; the nature, duration and purpose of the research study; the methods and means by which it is to be conducted; and the inconveniences and hazards that may reasonably be expected have been explained to me by

_____

I have been given an opportunity to ask questions concerning this investigational study. Any such questions were answered to my full and complete satisfaction. Should any further questions arise concerning my rights I may contact

_____

at _____

(Name, Address, and Phone Number of Hospital (Include Area Code))

I understand that I may at any time during the course of this study revoke my assent and withdraw from the study without further penalty or loss of benefits; however, I may be requested to undergo certain examination if, in the opinion of the attending physician, such examinations are necessary for my health and well-being. My refusal to participate will involve no penalty or loss of benefits to which I am otherwise entitled.

_____

PART B - TO BE COMPLETED BY INVESTIGATOR

INSTRUCTIONS FOR ELEMENTS OF INFORMED CONSENT: *(Provide a detailed explanation in accordance with Appendix E, AR 40-38 or AR 70-25.)*

See Part B attached.

I do ☐ do not ☐ *(check one & initial)* consent to the inclusion of this form in my outpatient medical treatment record.

SIGNATURE OF VOLUNTEER	DATE	SIGNATURE OF LEGAL GUARDIAN *(If volunteer is a minor)*
PERMANENT ADDRESS OF VOLUNTEER	TYPED NAME OF WITNESS	
	SIGNATURE OF WITNESS	DATE

REVERSE OF DA FORM 5303-R, MAY 88

Title: A Prelimary Assessment to Determine the Thermal Protective Capability of USMC Modular Sleeping Bag Candidates at -30°F.

Part B

You were presented a pretest briefing which verbally explained your involvment in the preliminary assessment of the thermal protective capability of candidate modular sleeping bags proposed by the USMC. Afterwards, you were given the opportunity to ask questions relative to your participation in the conduct of the test, and these were answered to your satisfaction before you volunteered to participate.

To reiterate, these tests will be conducted in a carefully controlled cold chamber to determine if the sleeping bags will provide you protection from the cold (-30°F). You will participate in a four hour test in the cold chamber for each of the 10 sleeping bag candidates. Each test will be conducted with the cold chamber set at -30°F. No tests will be conducted at temperatures less than -30°F. No more than one four hour test scenario will be conducted in a given day.

It is necessary to monitor your skin and body core temperatures for two reasons: (1) your personal safety; and (2) to collect data relative to your performance in the sleeping ensemble. You will be instrumented before dressing each day with four temperature sensors connected to read-out instrumentation located outside the chamber. These sensors will be placed as follows: Rectum, to measure inside body temperature; fingertip, large toe, and middle of back to measure skin temperatures. Observers outside the chamber will be monitoring these temperatures continually and recording all temperatures every 5 minutes. You will be removed from any individual test at any time your rectal temperature goes down to 95.0°F or any skin temperature goes below 50°F. At these temperatures you may be uncomfortable, but at no risk whatever of cold injury.

Since you are a volunteer participant, Army Regulations (AR 40-38 and AR 70-25) require that your medical records be reviewed prior to your participation in a study. Since you are being asked to participate in a study where you will be exposed to low ambient air temperatures in an environmental chamber, your records will be medically screened by US Naval medical officers. This is to assure that you have not had a history of cold intolerance or cold injury, alcoholism, or circulatory disorder; and to assure that you are not or have not recently used medications which may interfere with body temperature regulation or shivering.

You will receive no direct benefits from your participation in this study other than the knowledge and experience you may gain. However, the results of these tests will help the USMC in the selection of an efficient modular sleeping bag system.

All data and medical information obtained about you as an individual will be considered priviledged and held in confidence. Complete confidentiality can not be promised because information bearing on your health may be required to be reported to appropriate medical or command authorities.

The results of these tests will be confidential; that is, your identities will not be associated with published tests results. You have the right of access to any of the data collected on you. Any questions about this data access should be addressed to the test director, Mr. William E. Hanlon.

APPENDIX B

QUESTIONNAIRE

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Subject Name _____ Subject No._____

Modular Sleeping Bag _____ Date _____

Directions: You have just completed a scenario in which you have used one of the candidate modular sleeping bags being evaluated. Please answer the questions and rate this sleeping bag based on the experience you had during this scenario. You are also encouraged to write any additional comments (favorable or unfavorable) you may have in the space provided on the back of this page.

1. Were you able to warm yourself after entering the sleeping bag?

   [] Yes
   [] No (explain)

2. If you were able to warm yourself after entering the sleeping bag,

   a. How long did it take to feel comfortably warm?

   b. Did you remain warm for the entire exposure period?

3. Were you able to sleep during the four-hour exposure period?

   [] Yes - For approximately how long? _____
   [] No (explain if it was due to being cold or just not able to sleep)

4. If you could not sleep, were you able to rest comfortably during the four-hour exposure period?

   [] Yes
   [] No (explain)

5. Did you feel any cold spots in any area of this sleeping bag at any time during the scenario?

   [] No
   [] Yes (If yes, describe location of cold spot areas:

Directions: Rate the sleeping bag you just used by placing an "X" in the box that best describes your opinion about the rating. Use the rating scale below as a guideline:

EXCELLENT [5]	GOOD [4]	ACCEPTABLE [3]	MARGINAL [2]	UNACCEPTABLE [1]

How would you rate:	[5]	[4]	[3]	[2]	[1]
Quality of rest or sleep	[ ]	[ ]	[ ]	[ ]	[ ]
Comfort	[ ]	[ ]	[ ]	[ ]	[ ]
Ability to keep you warm	[ ]	[ ]	[ ]	[ ]	[ ]
Amount of room inside bag	[ ]	[ ]	[ ]	[ ]	[ ]
Ability to change body position	[ ]	[ ]	[ ]	[ ]	[ ]
Length	[ ]	[ ]	[ ]	[ ]	[ ]
Width	[ ]	[ ]	[ ]	[ ]	[ ]
Size and shape of hood	[ ]	[ ]	[ ]	[ ]	[ ]
Closure for hood	[ ]	[ ]	[ ]	[ ]	[ ]
Size and shape of footbox	[ ]	[ ]	[ ]	[ ]	[ ]

Additional Comments:

APPENDIX C

TIME VERSUS TEMPERATURE GRAPHS

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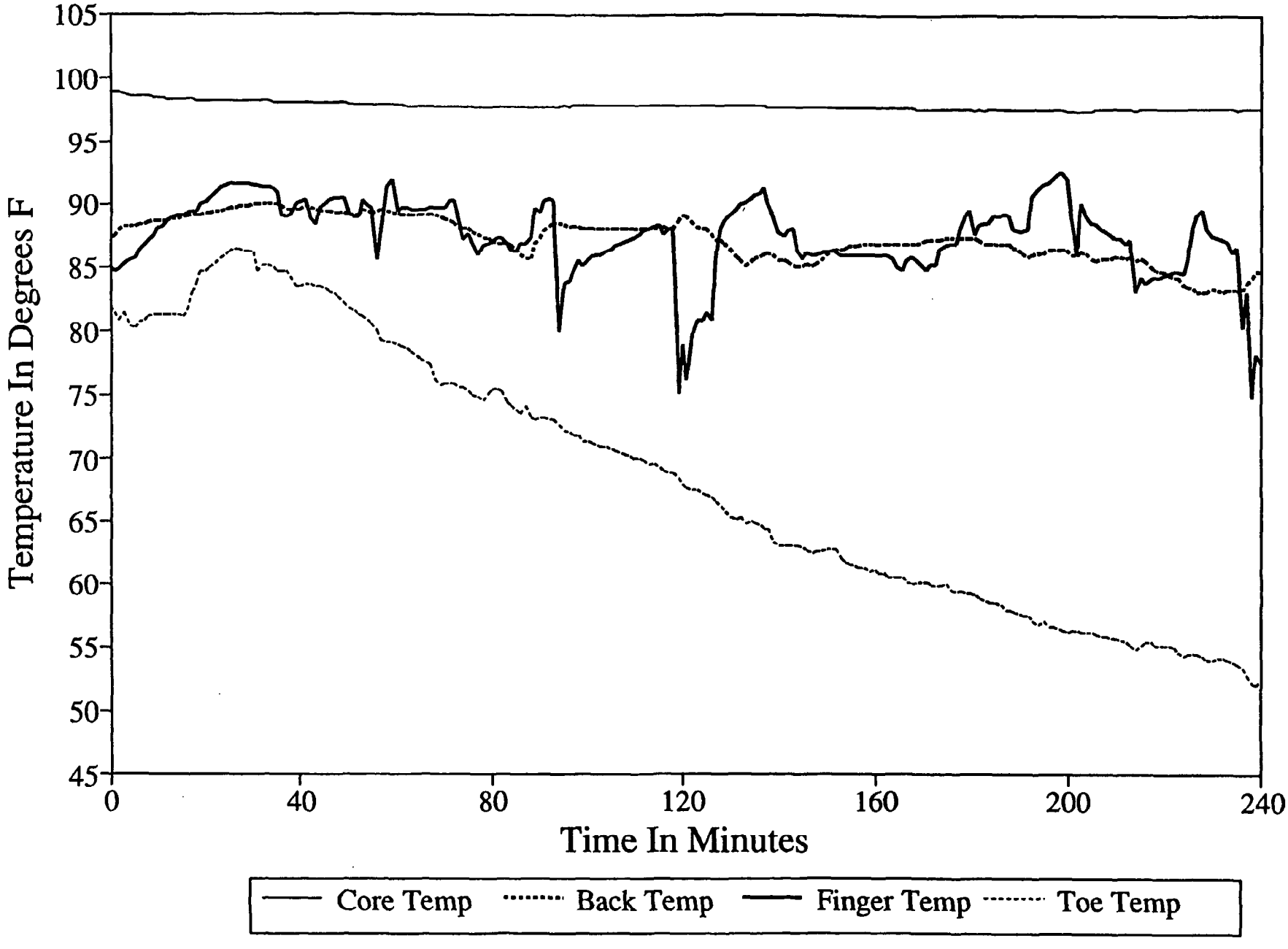

Figure C-1. Subject 1 in sleep system A.

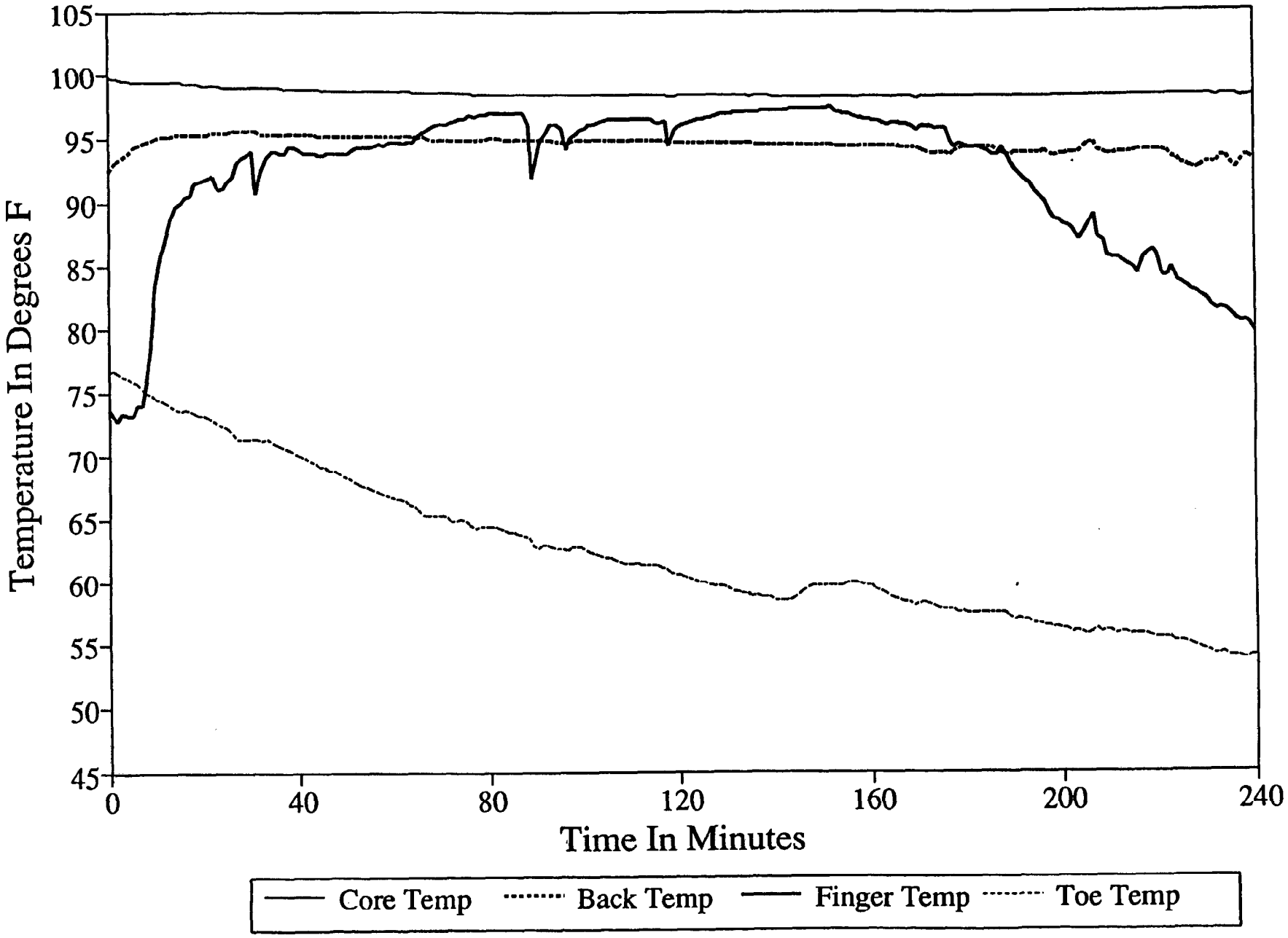

Figure C-2. Subject 2 in sleep system A.

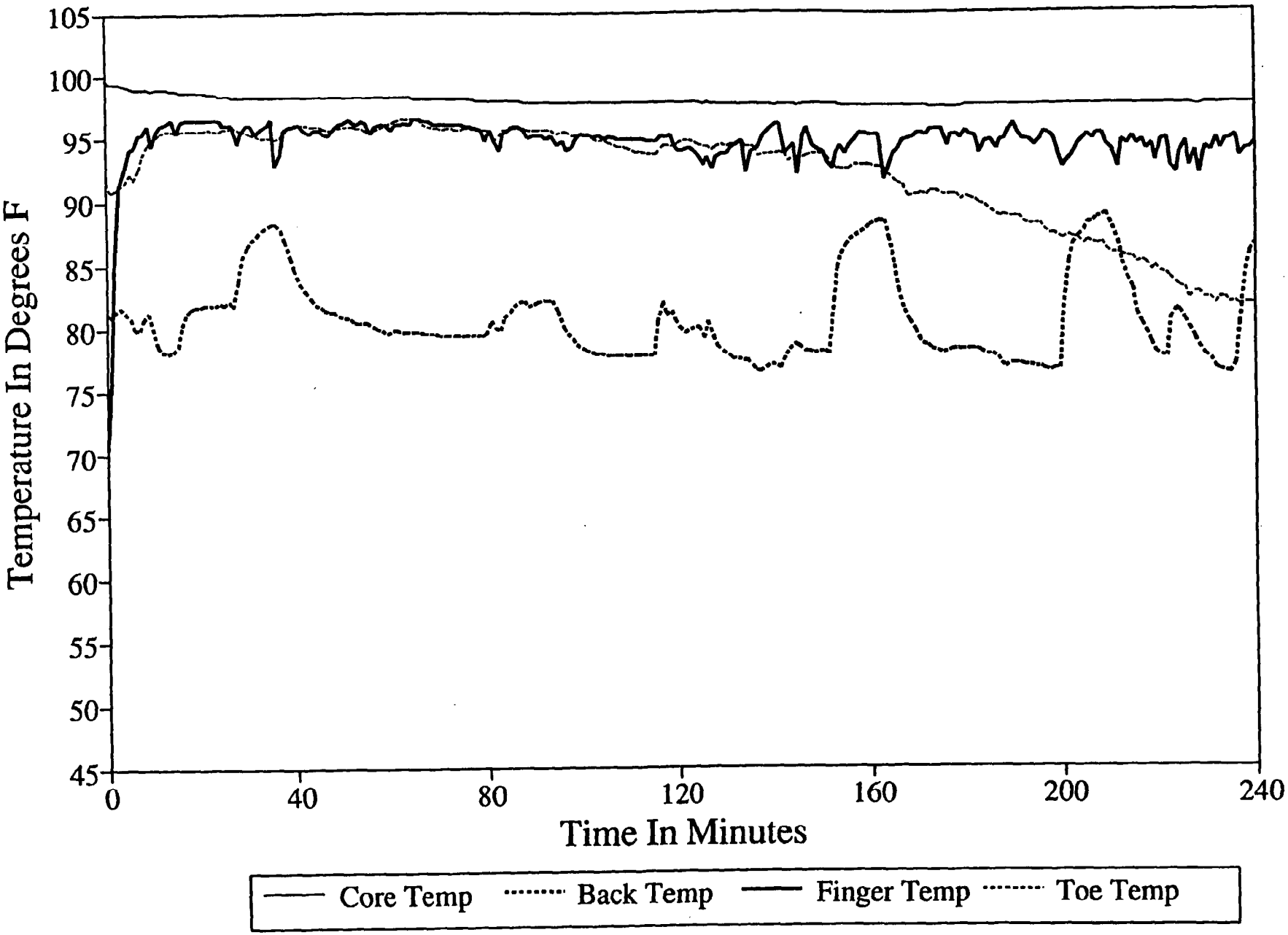

Figure C-3. Subject 3 in sleep system A.

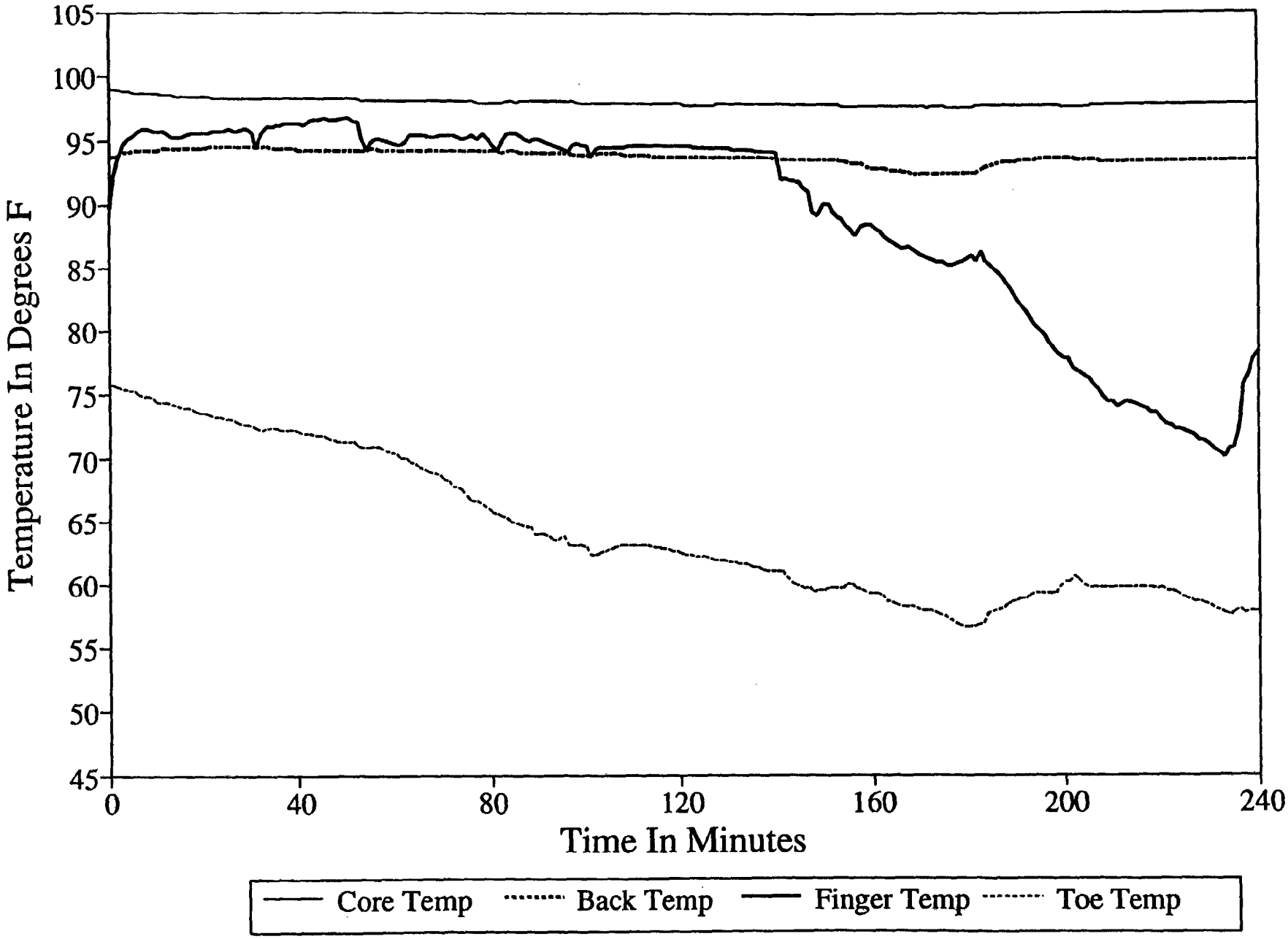

Figure C-4. Subject 4 in sleep system A.

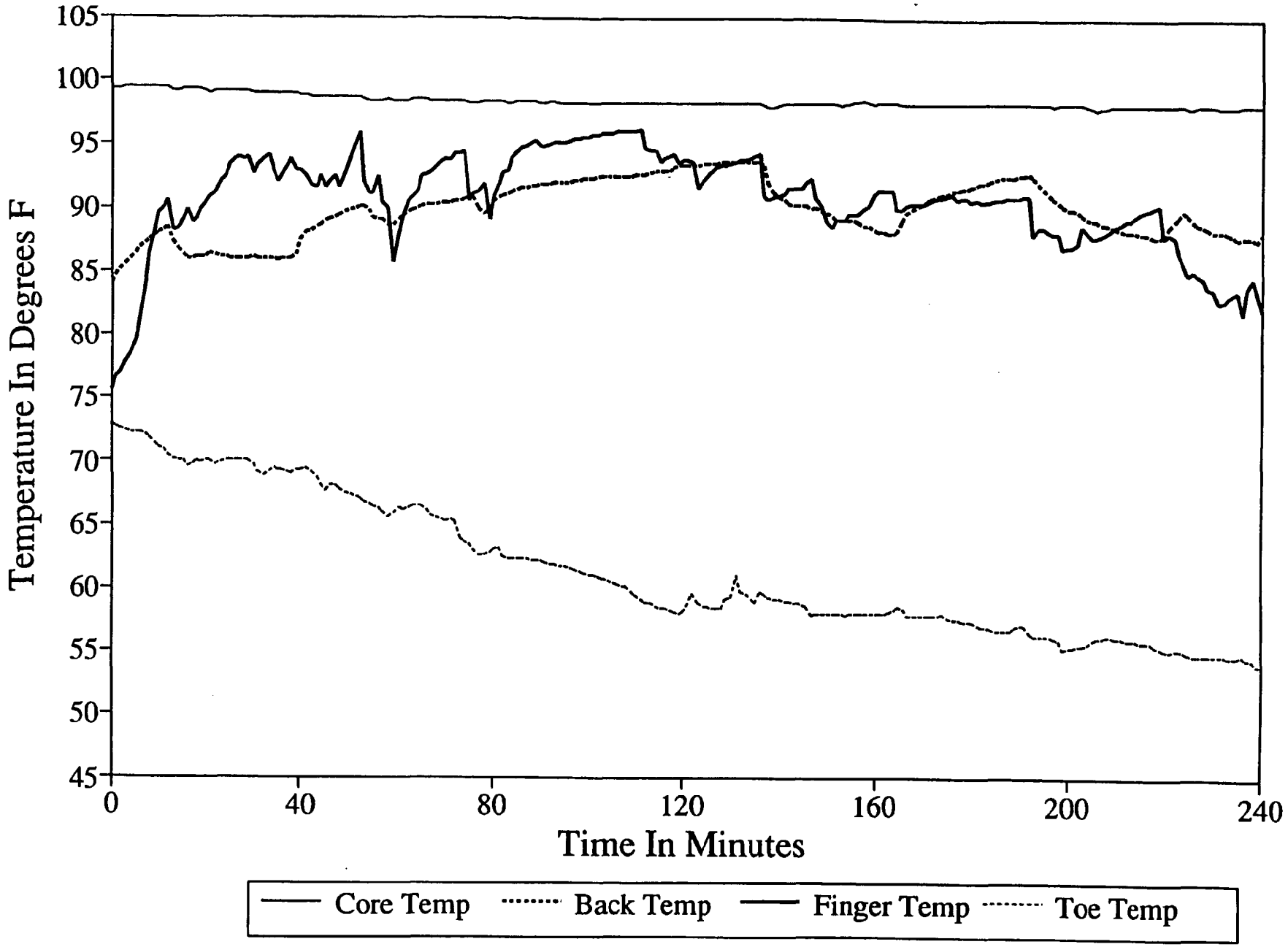

Figure C-5. Subject 1 in sleep system B.

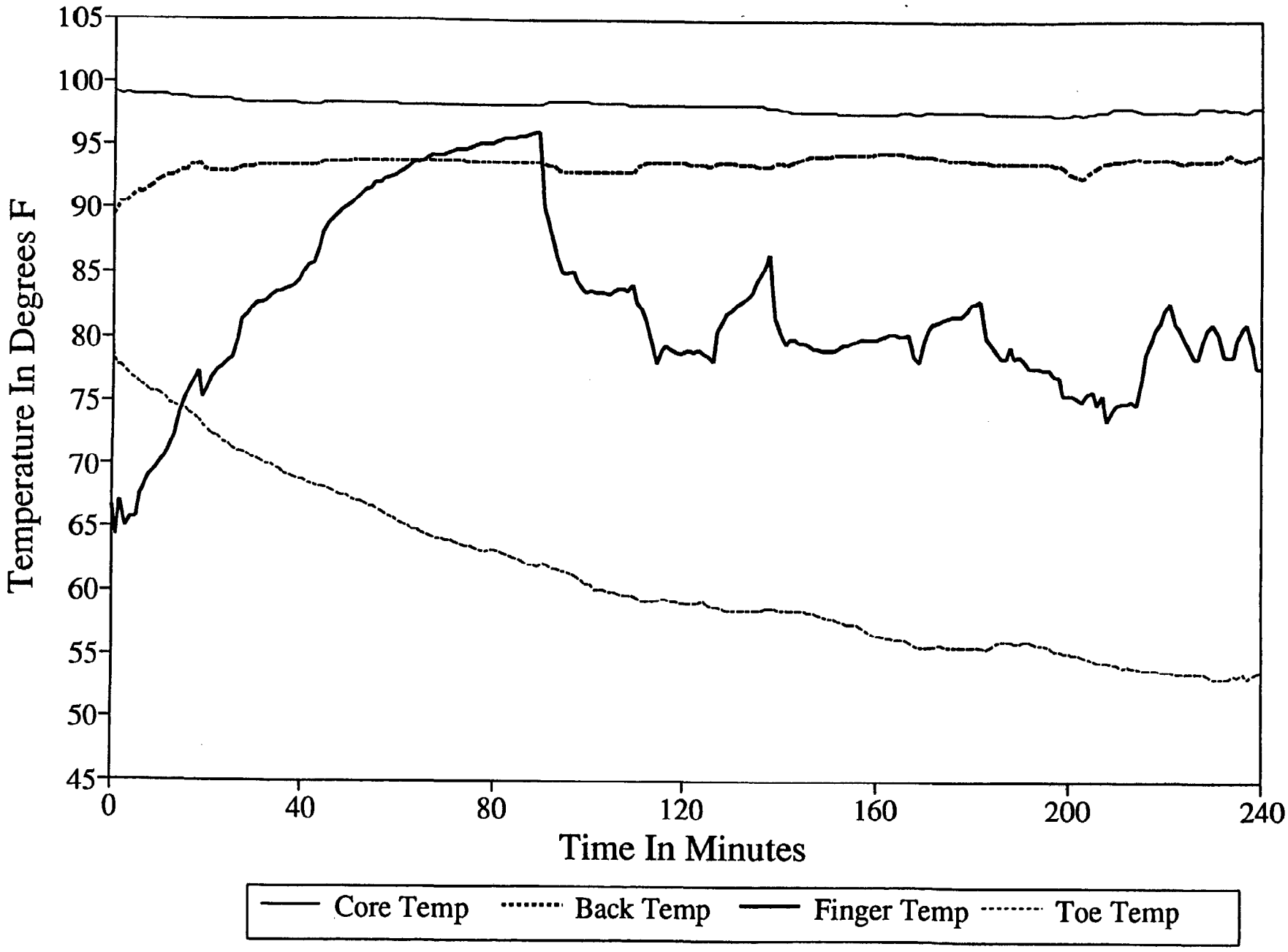

Figure C-6. Subject 2 in sleep system B.

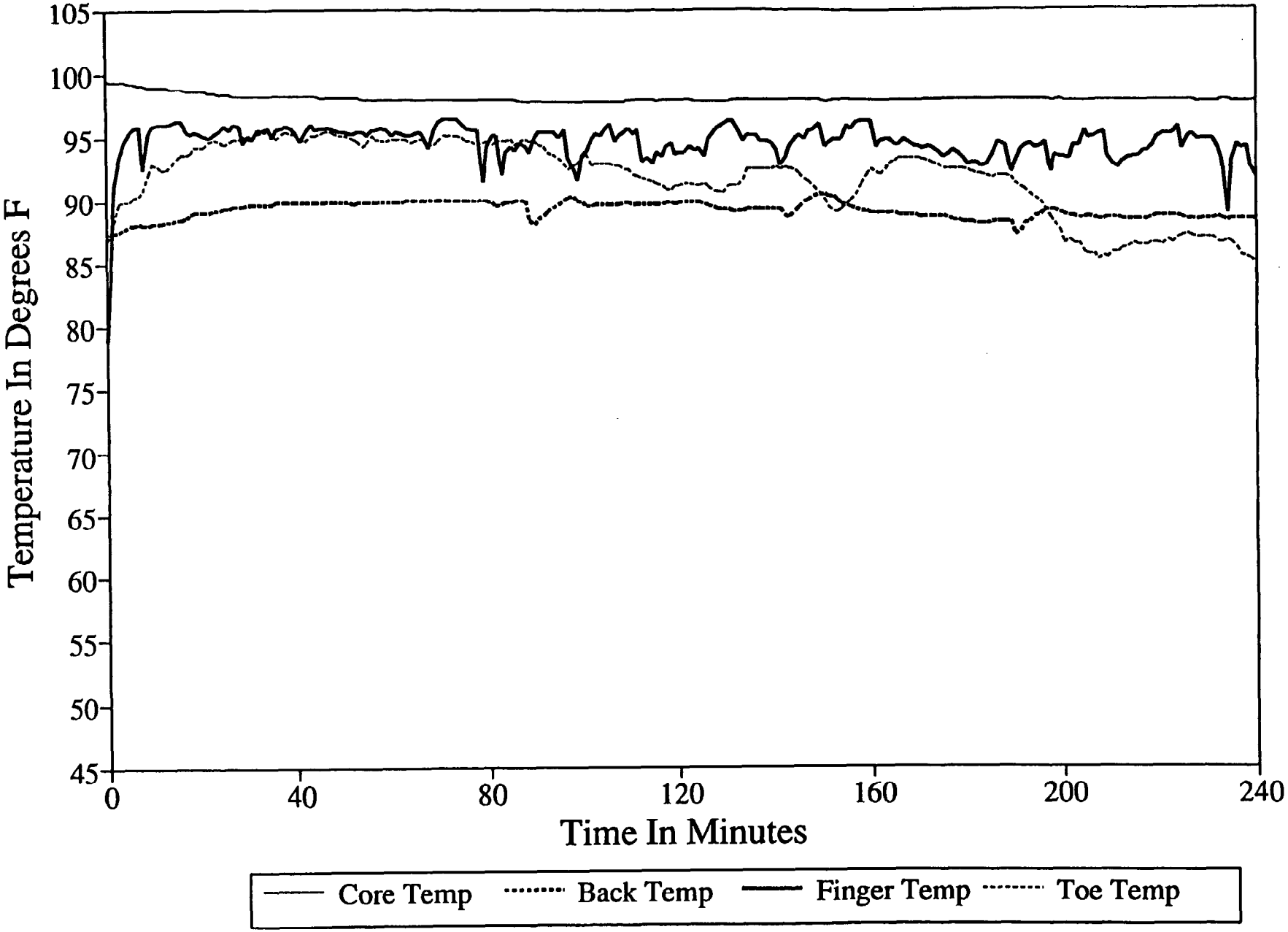

Figure C-7. Subject 3 in sleep system B.

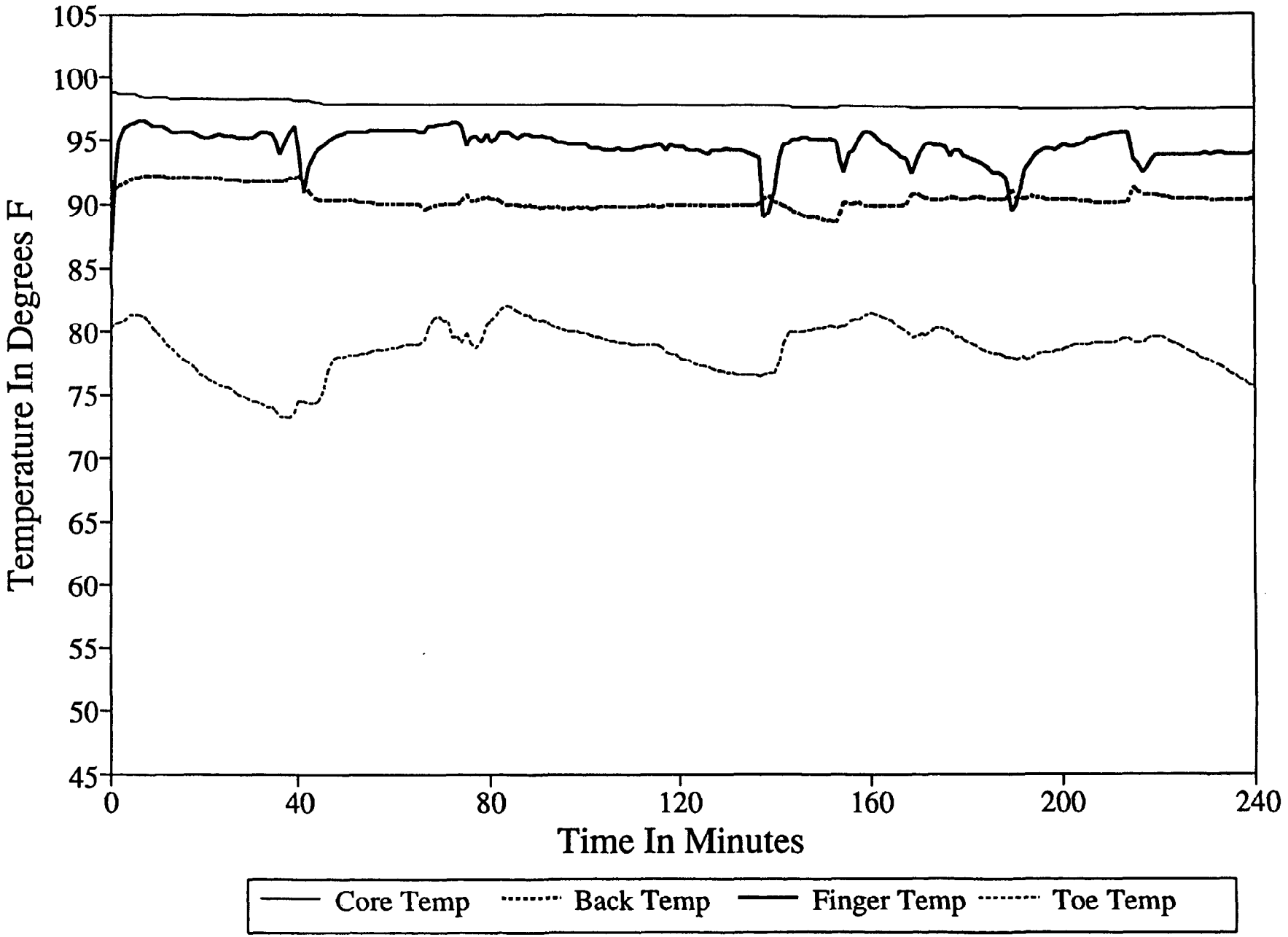

Figure C-8. Subject 4 in sleep system B.

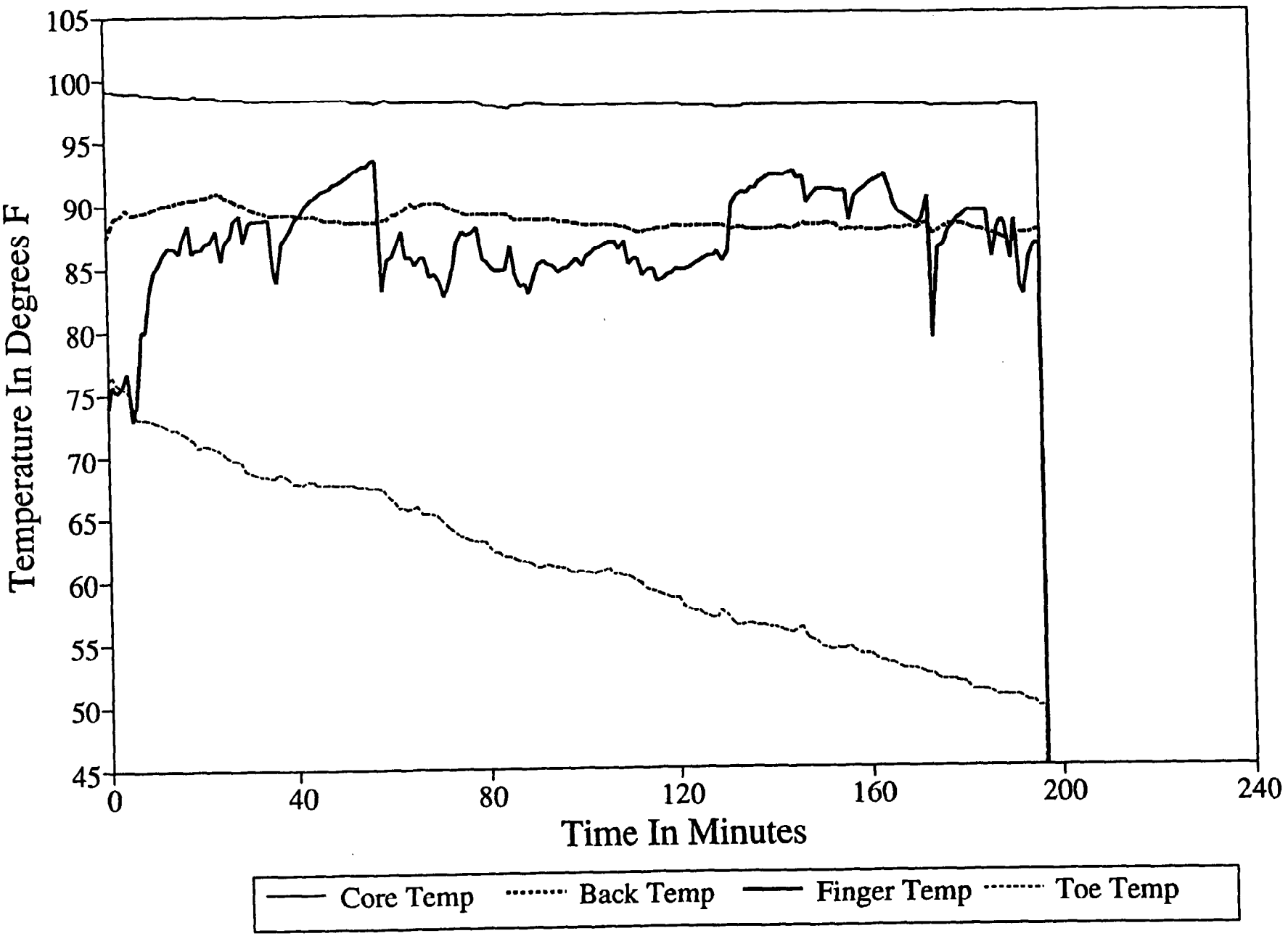

Figure C-9. Subject 1 in sleep system C.

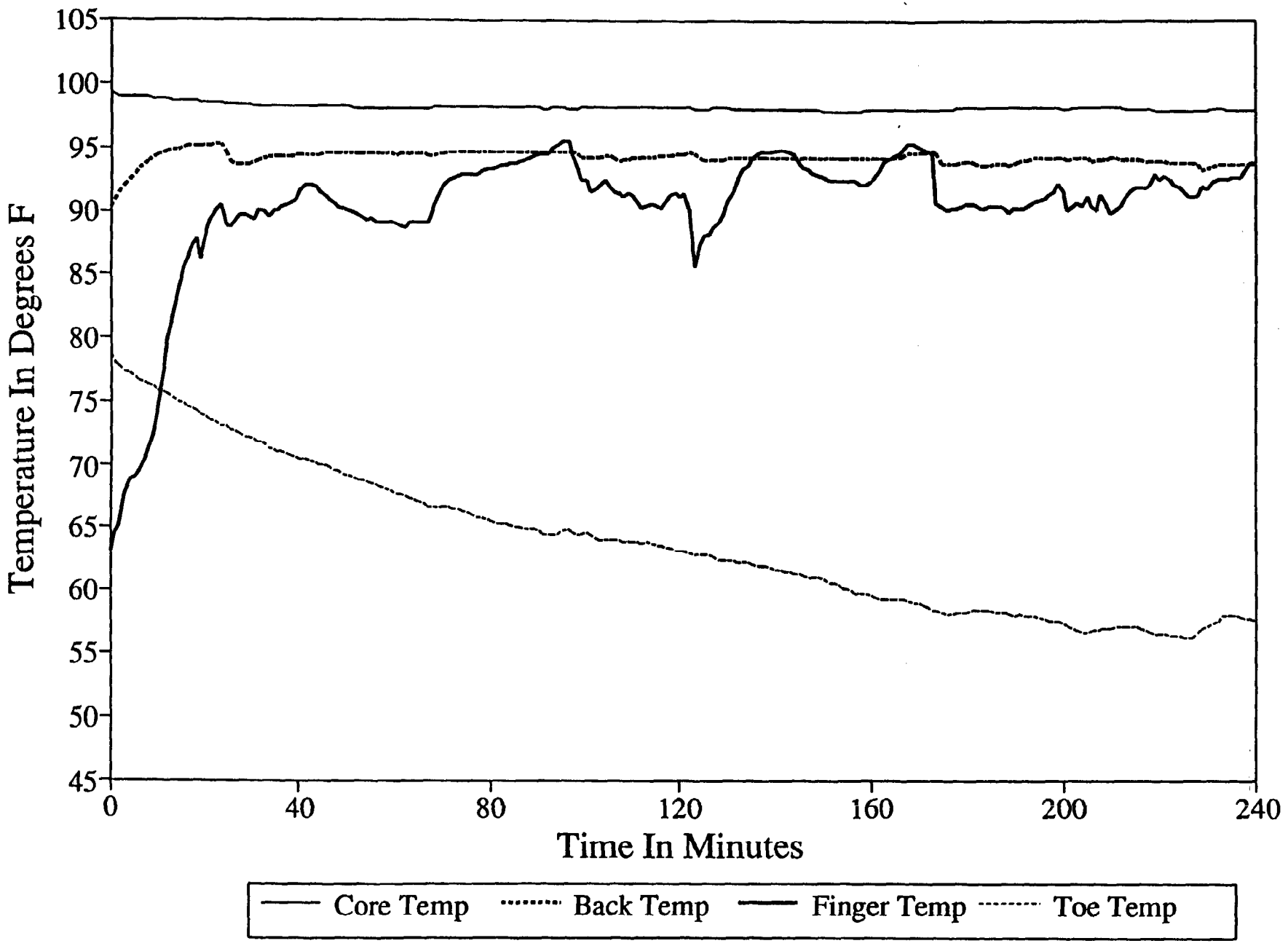

Figure C-10. Subject 2 in sleep system C.

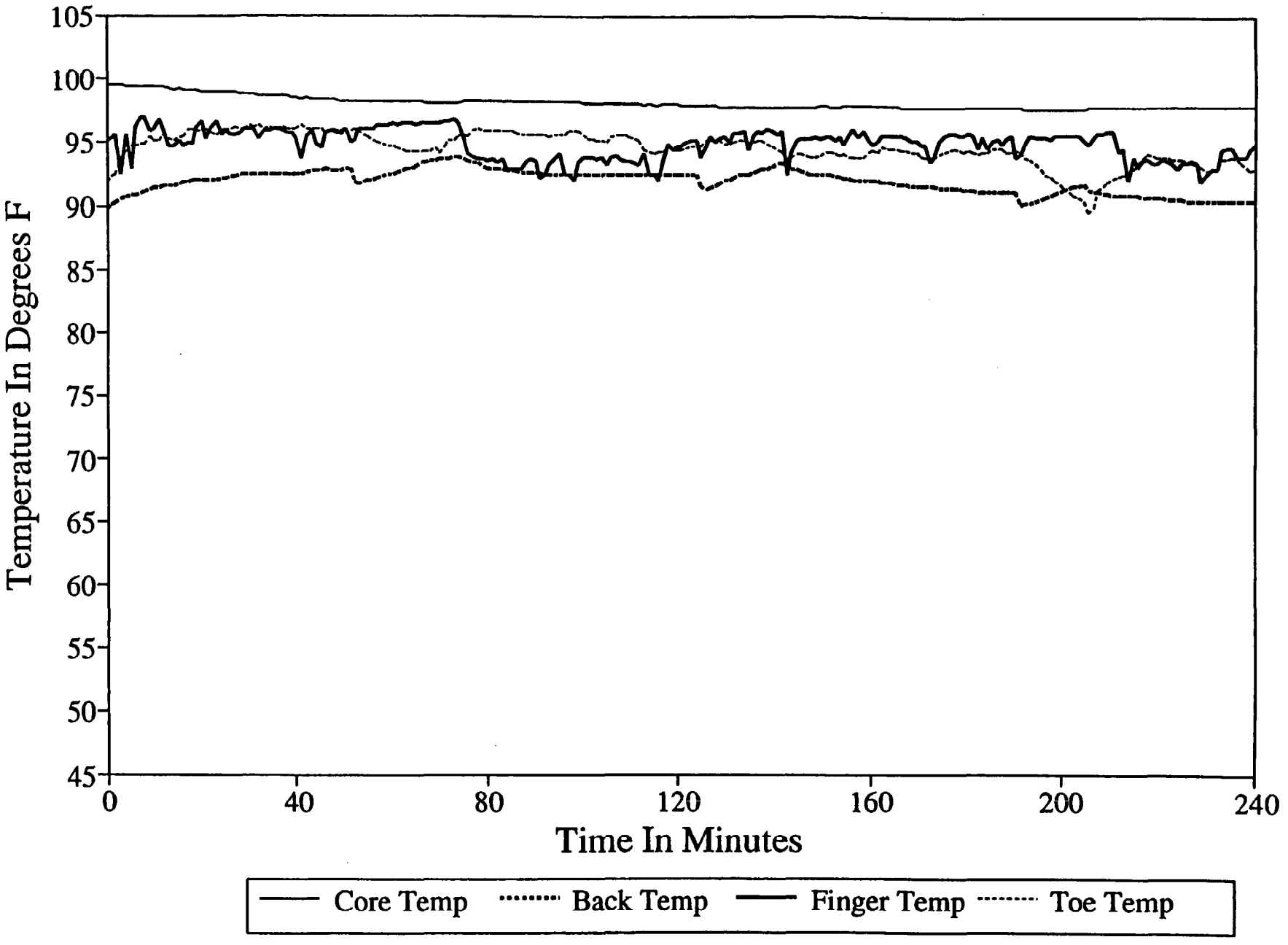

Figure C-11. Subject 3 in sleep system C.

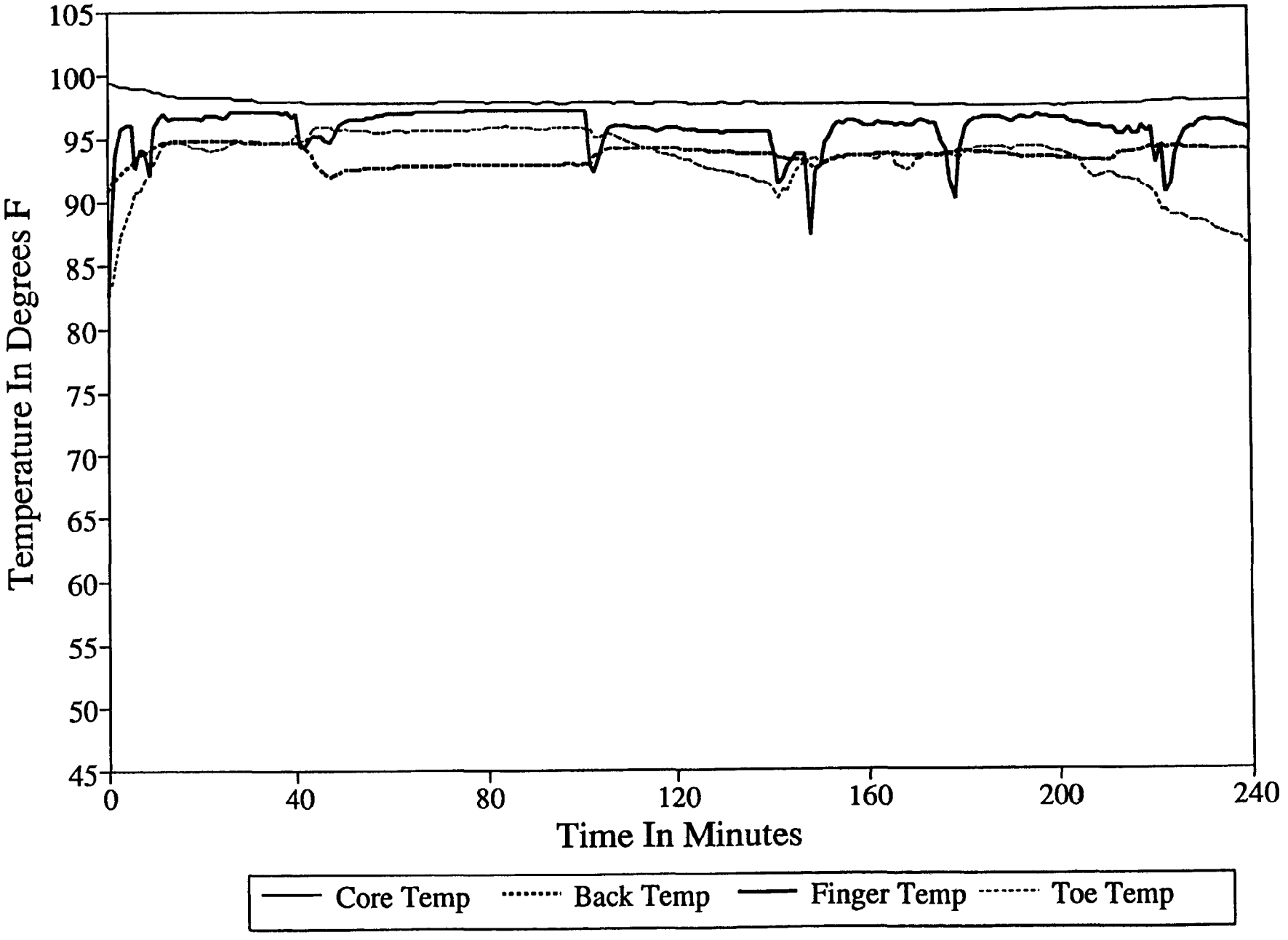

Figure C-12. Subject 4 in sleep system C.

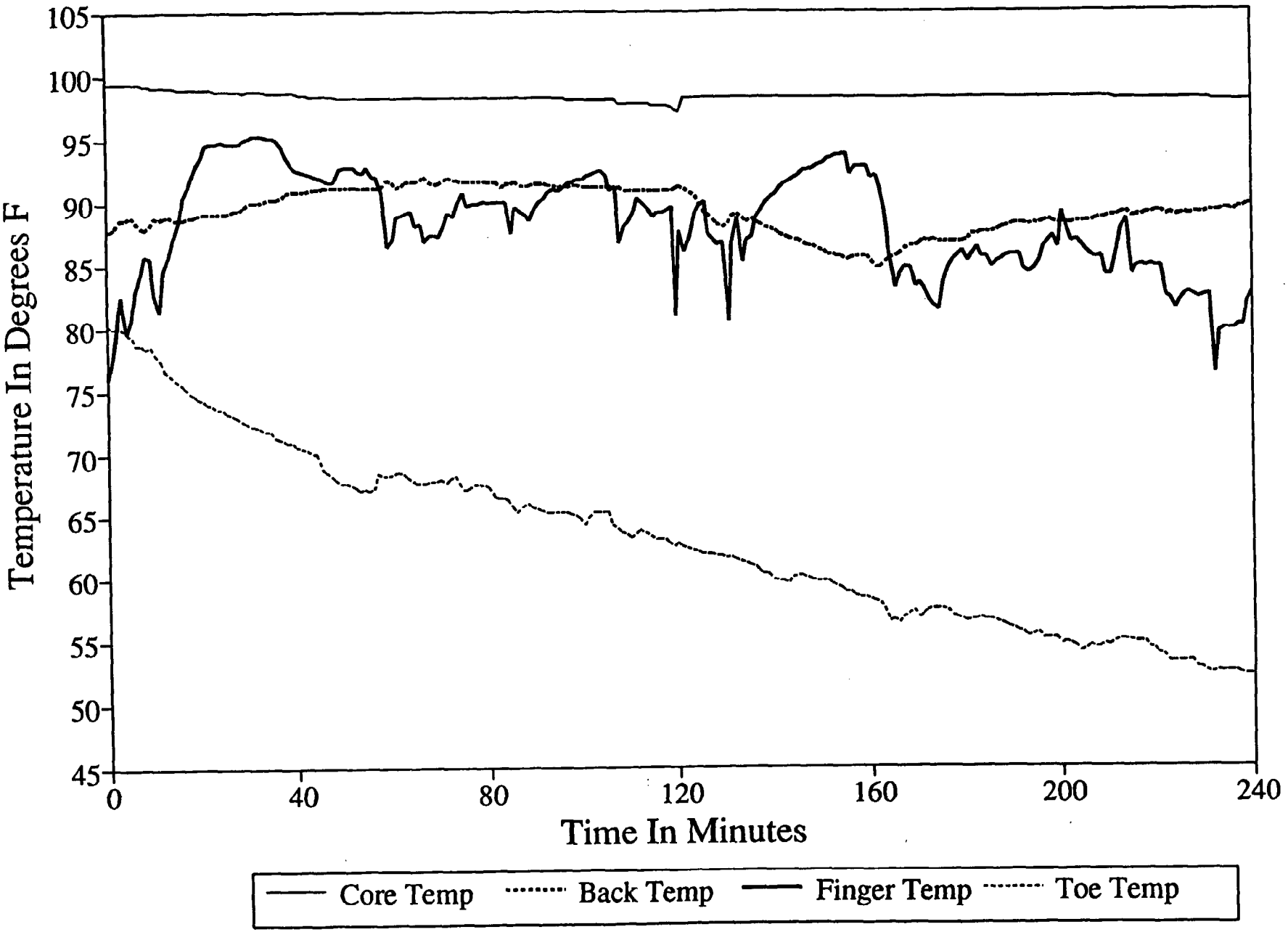

Figure C-13. Subject 1 in sleep system D.

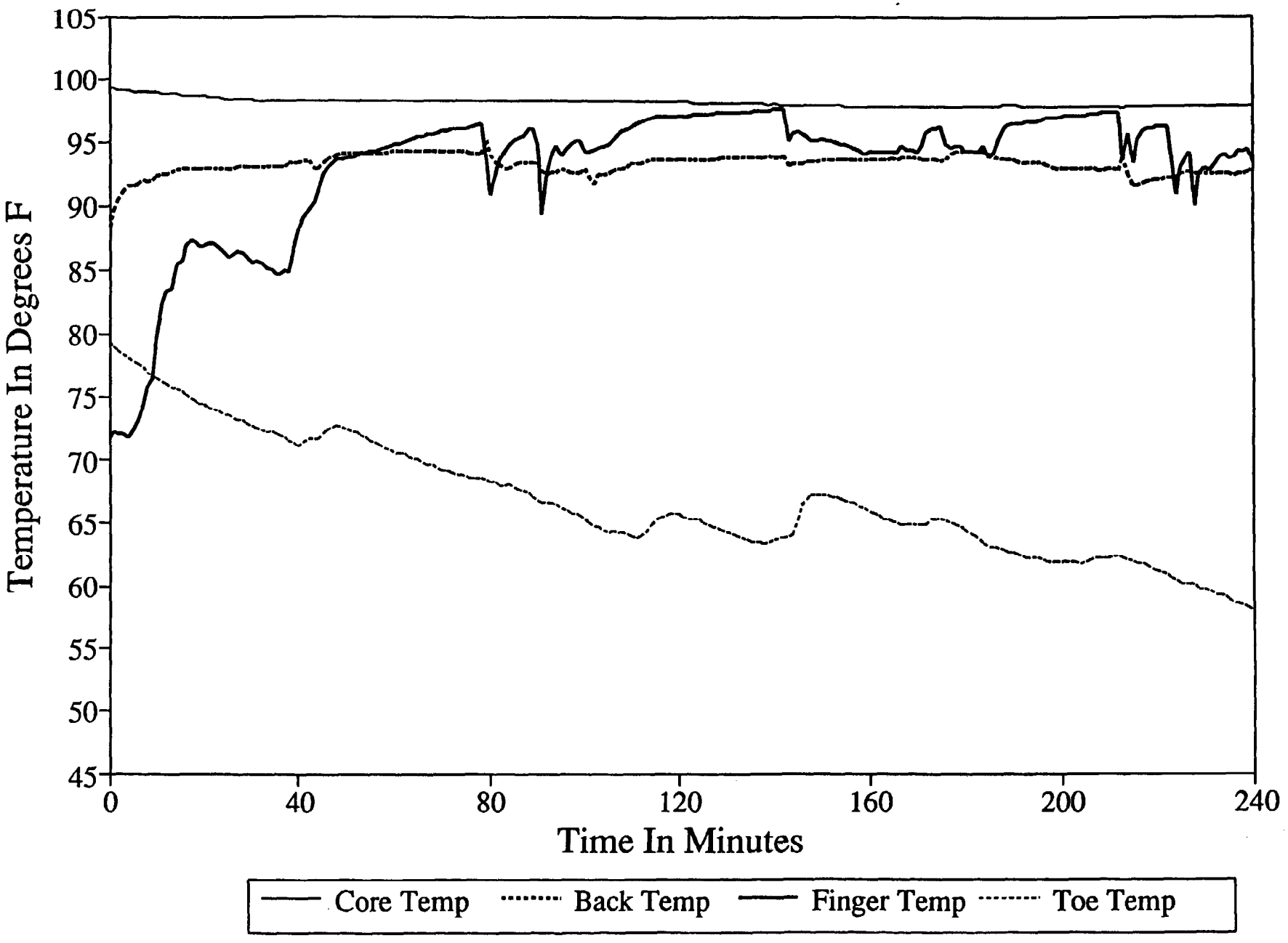

Figure C-14. Subject 2 in sleep system D.

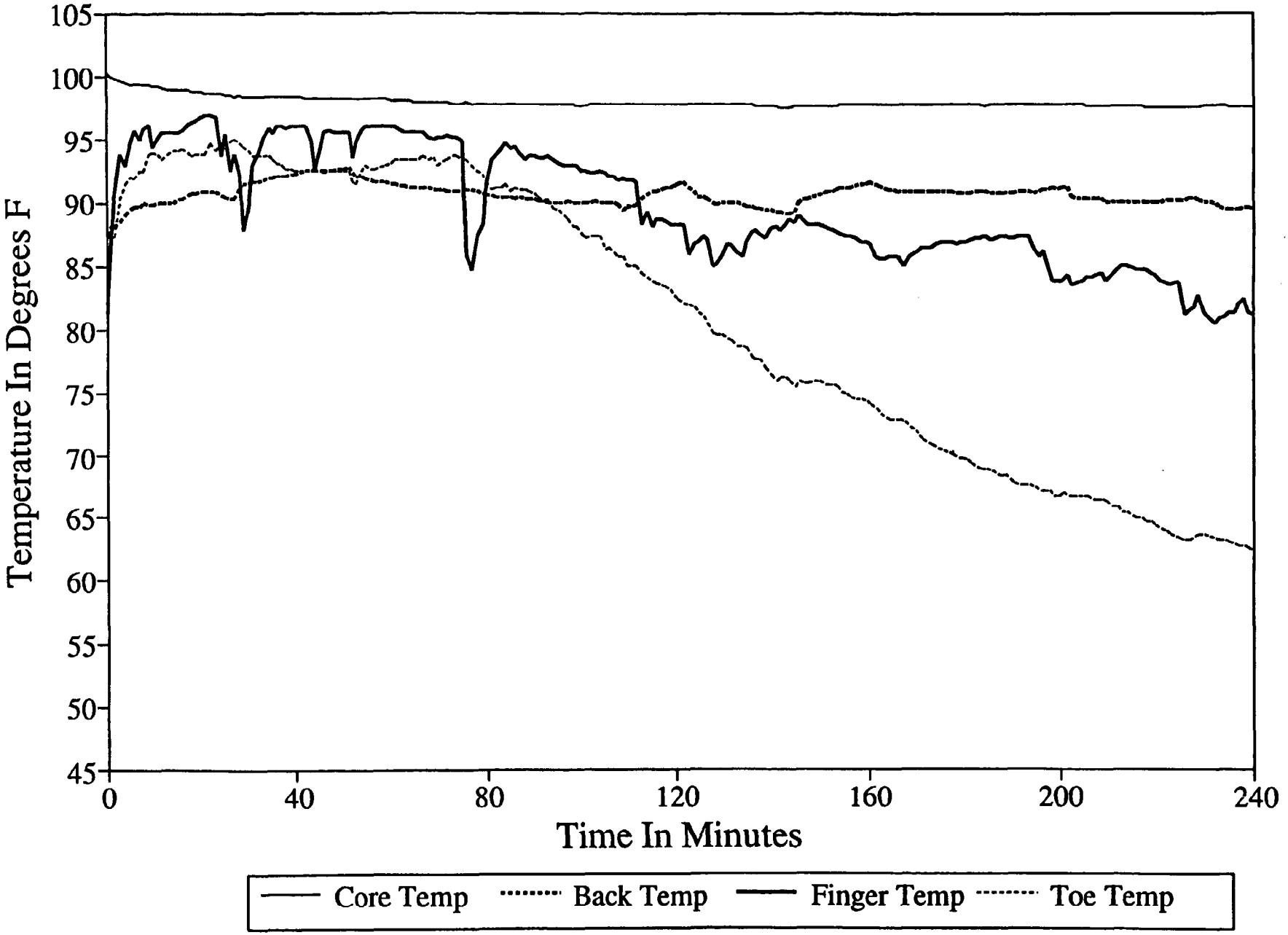

Figure C-15. Subject 3 in sleep system D.

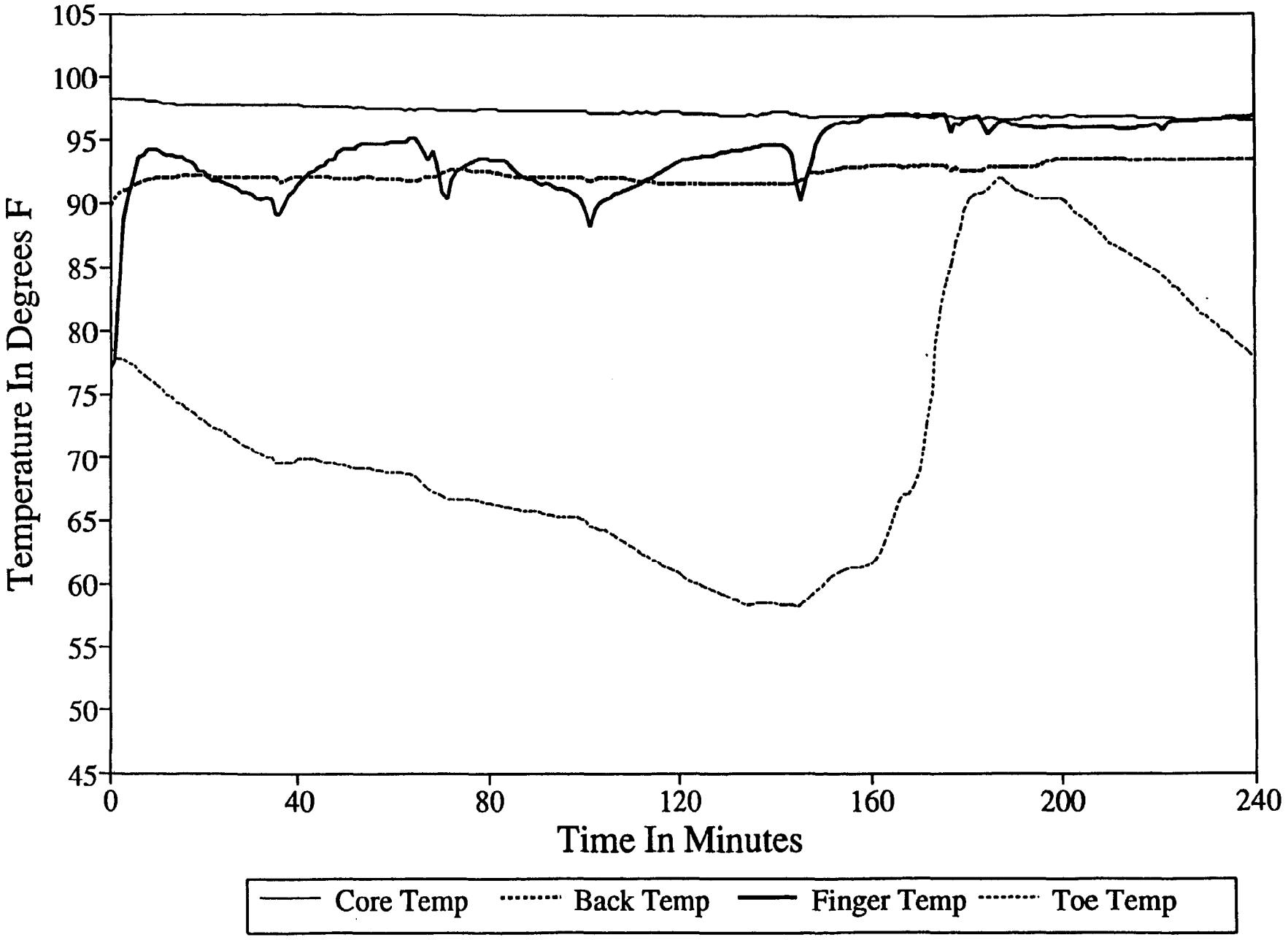

Figure C-16. Subject 4 in sleep system D.

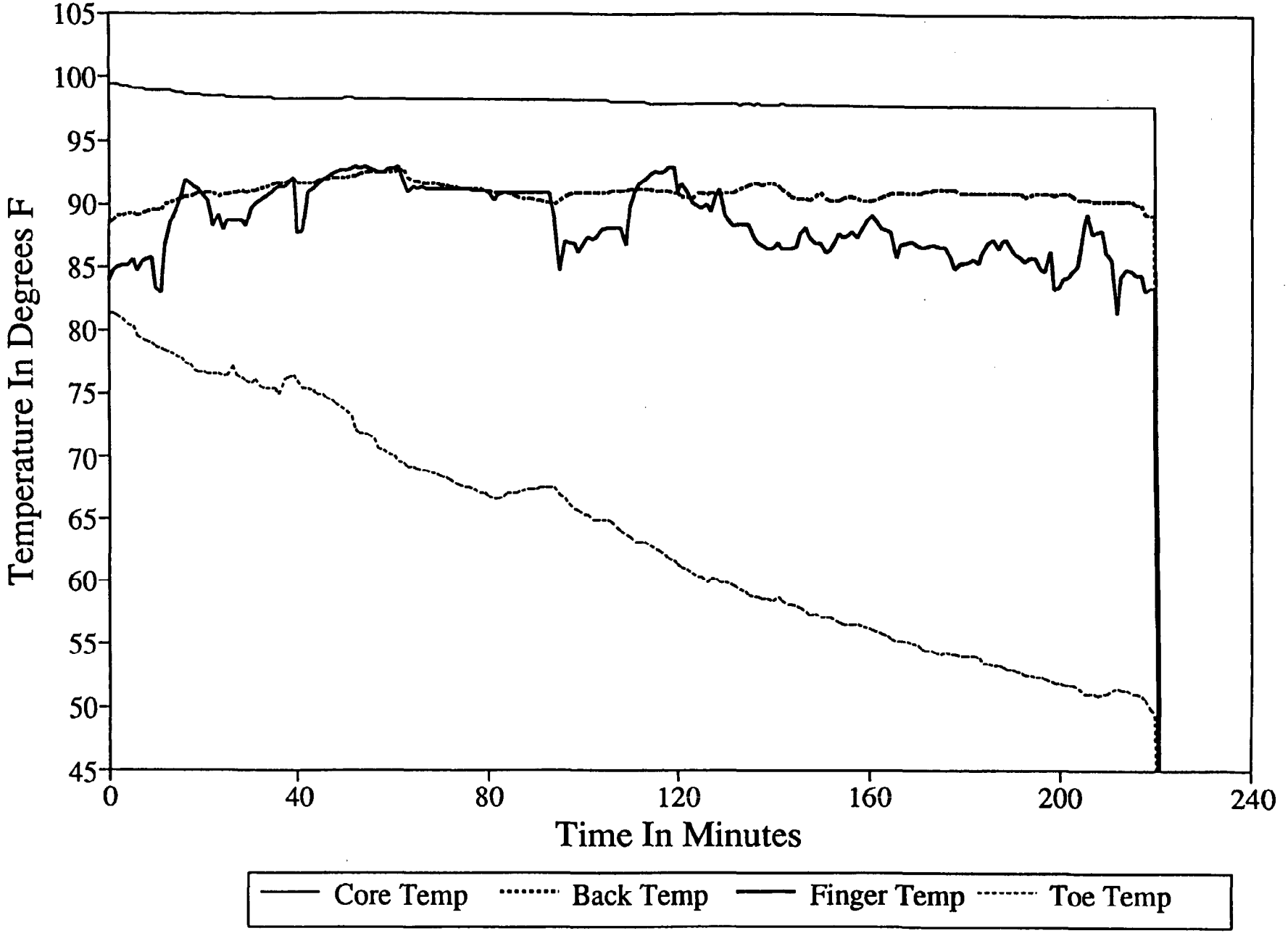

Figure C-17. Subject 1 in sleep system E.

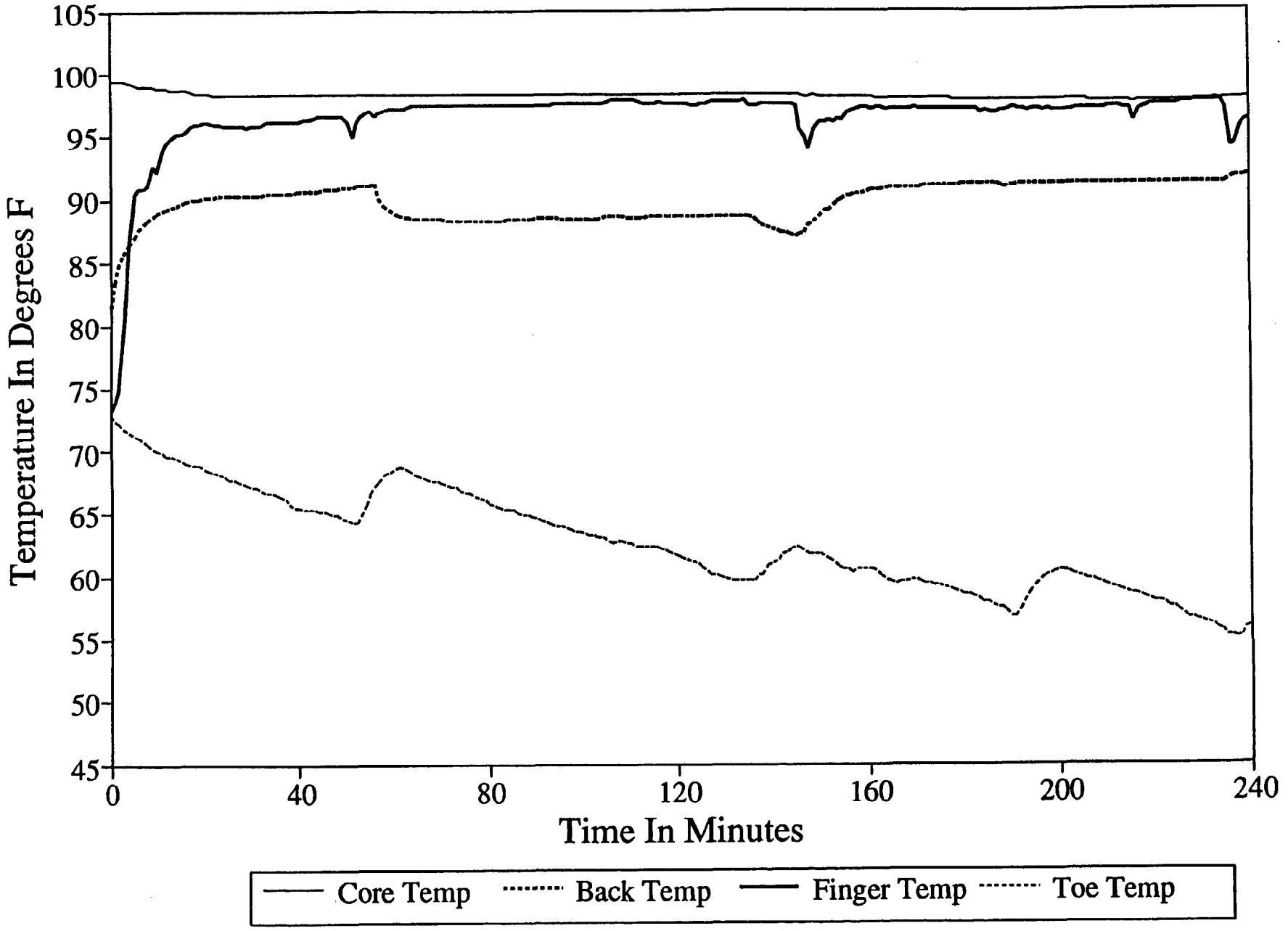

Figure C-18. Subject 2 in sleep system E.

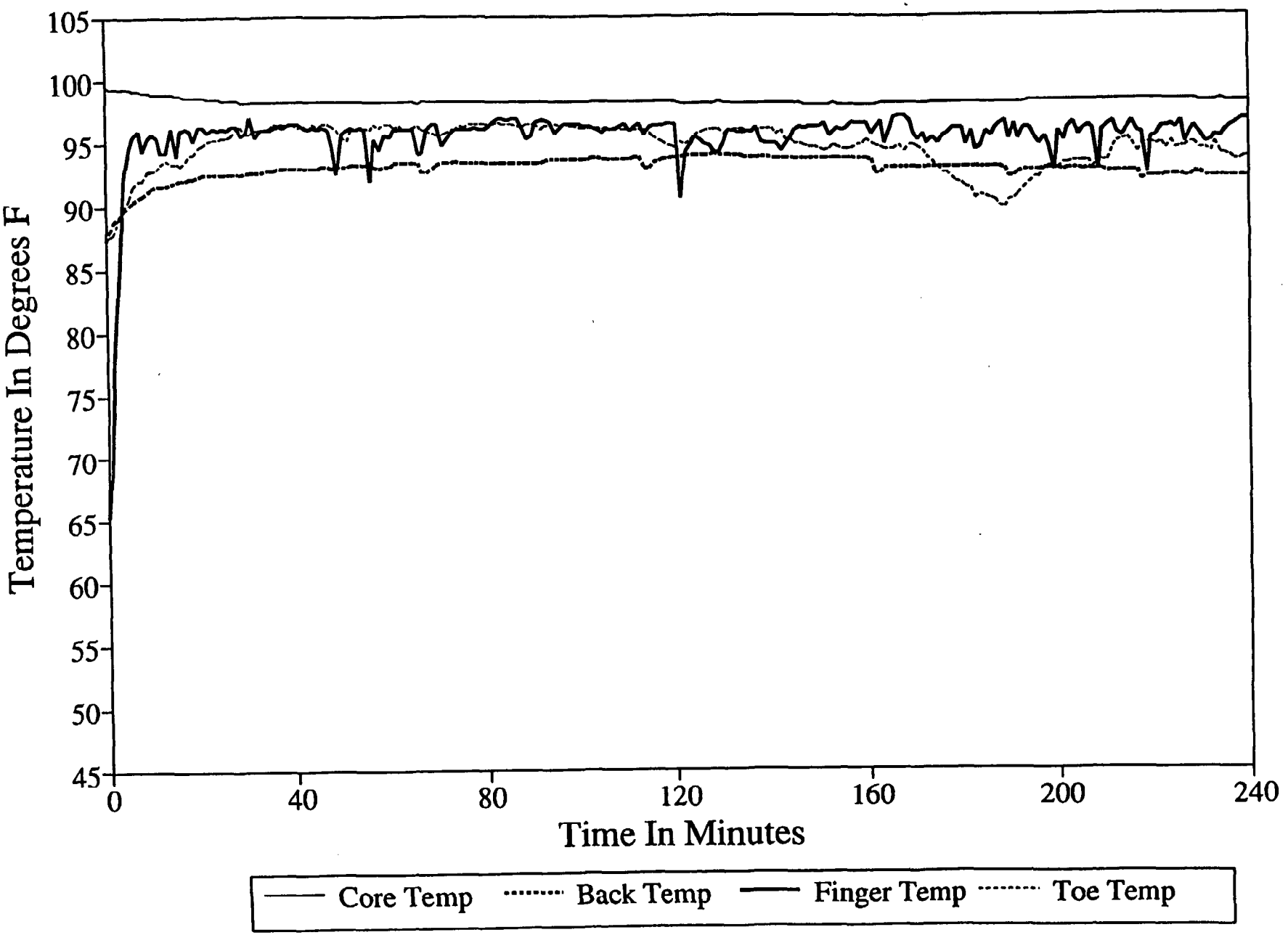

Figure C-19. Subject 3 in sleep system E.

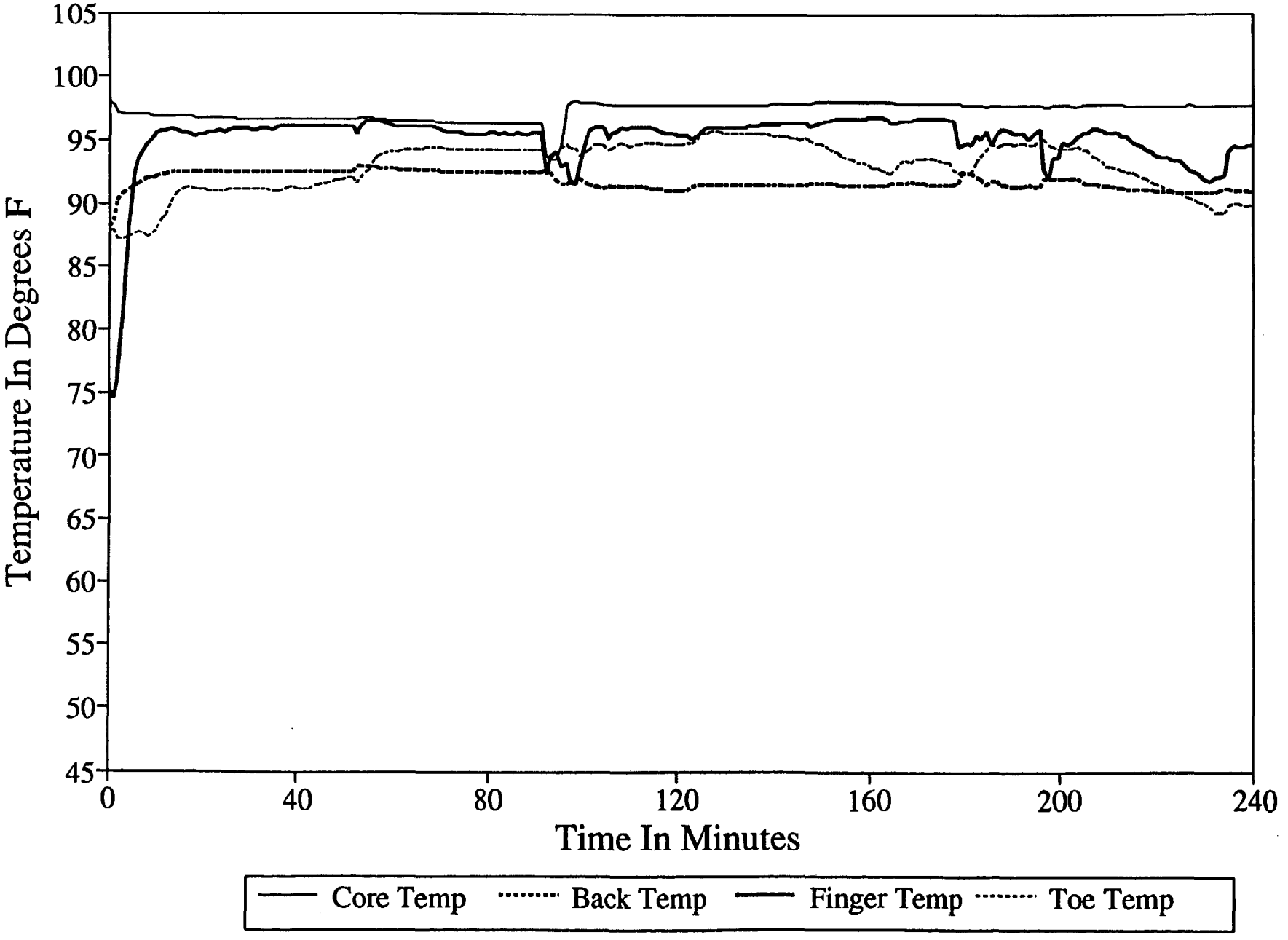

Figure C-20. Subject 4 in sleep system E.

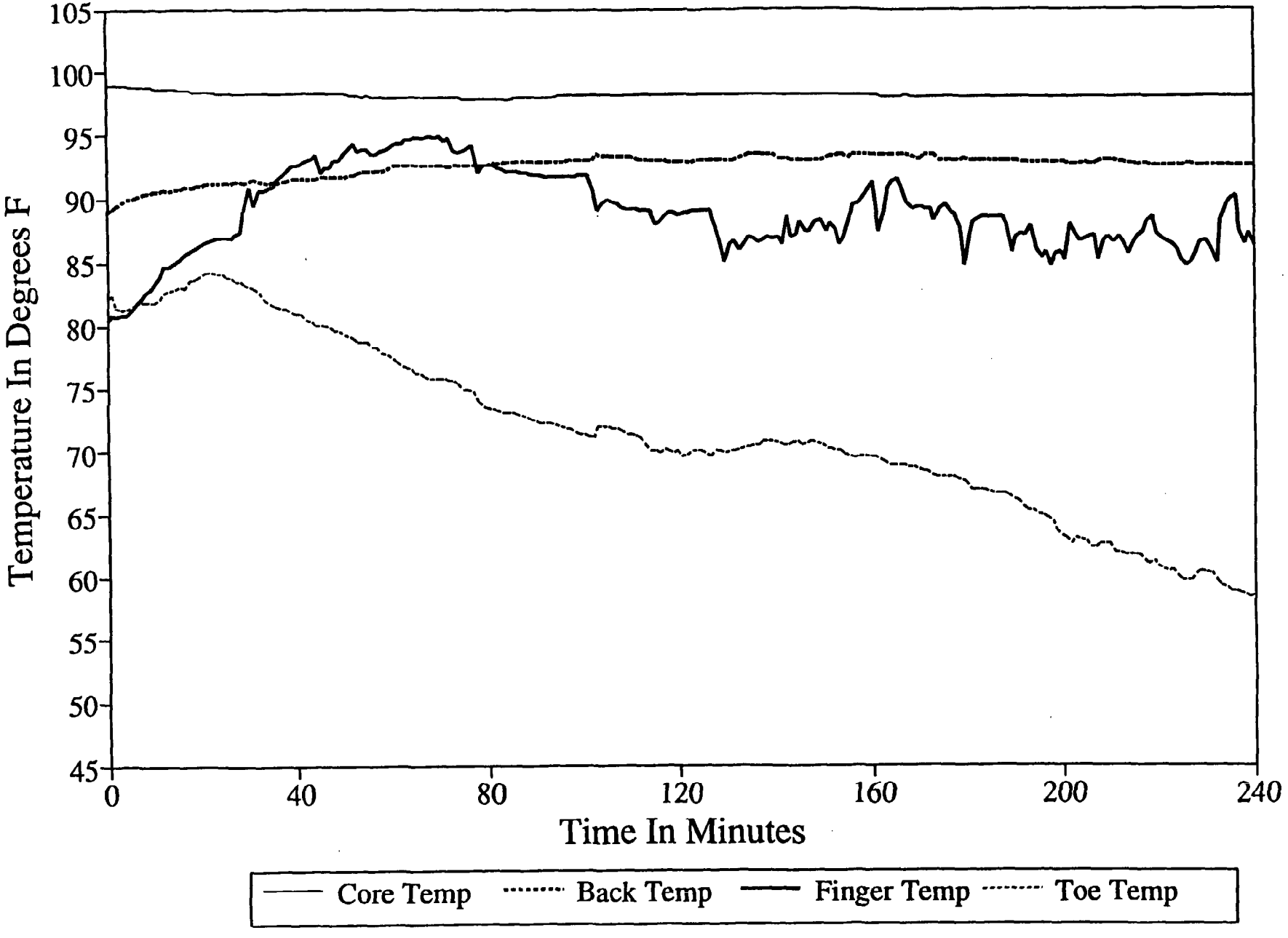

Figure C-21. Subject 1 in sleep system F.

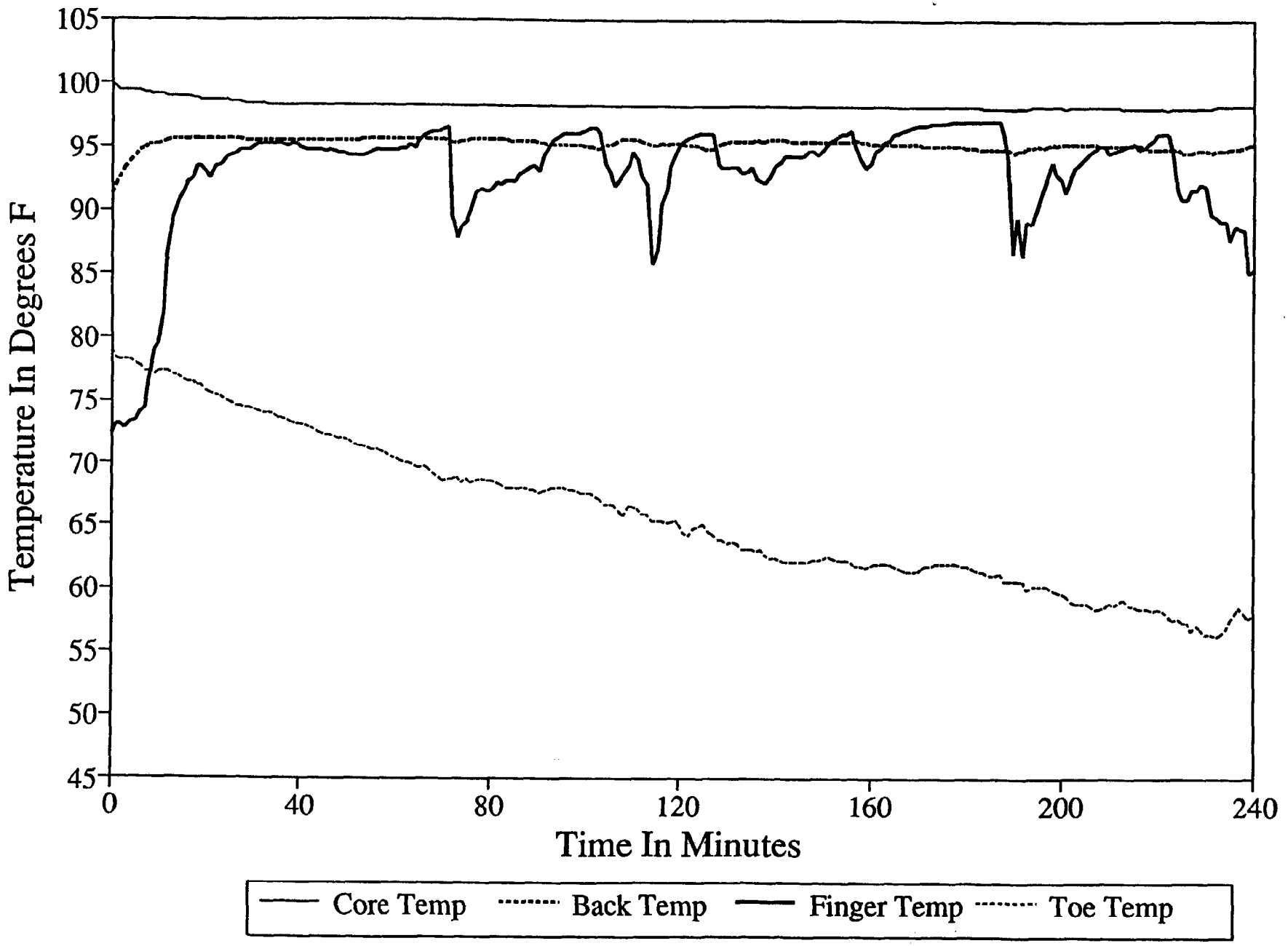

Figure C-22. Subject 2 in sleep system F.

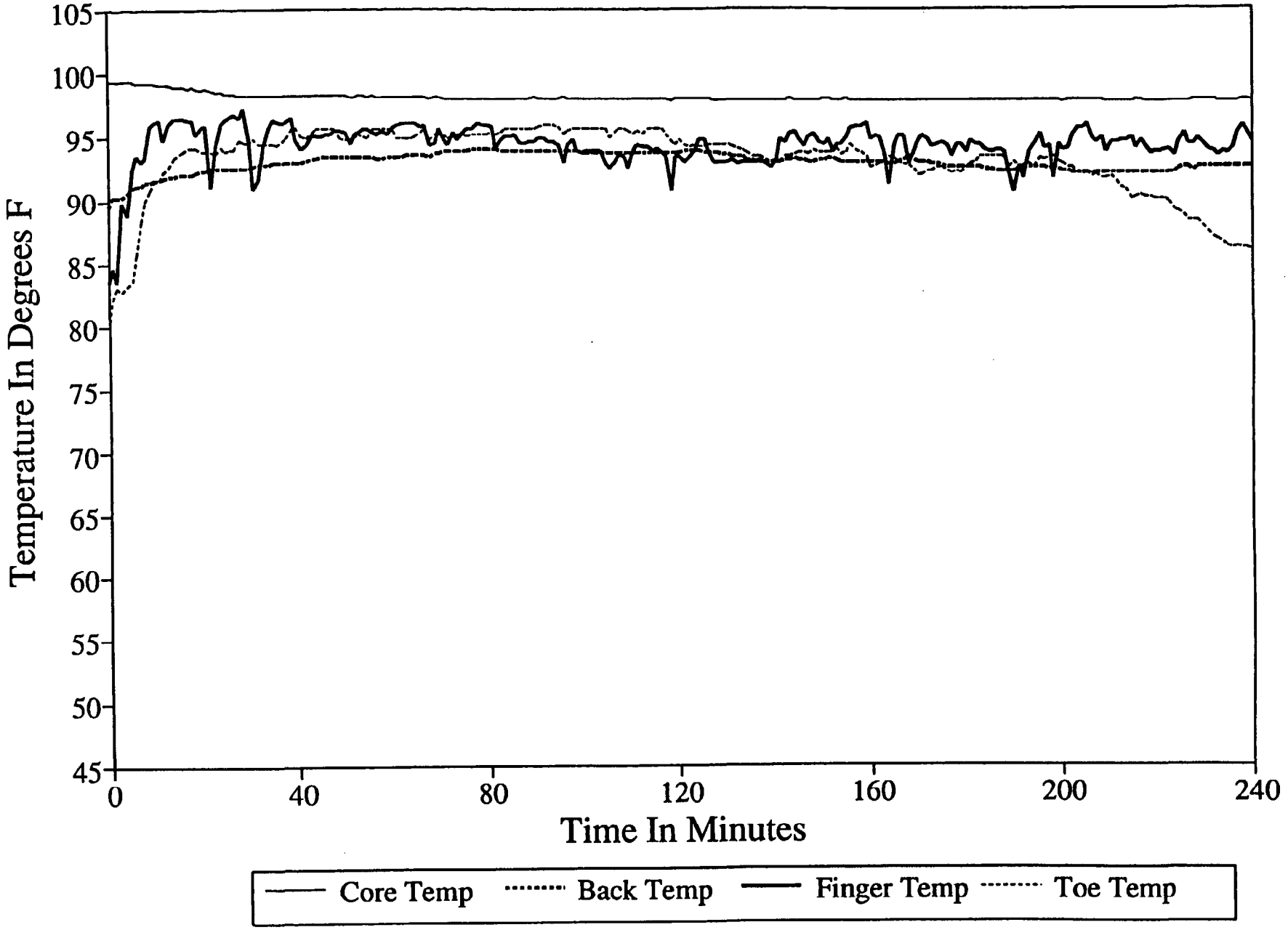

Figure C-23. Subject 3 in sleep system F.

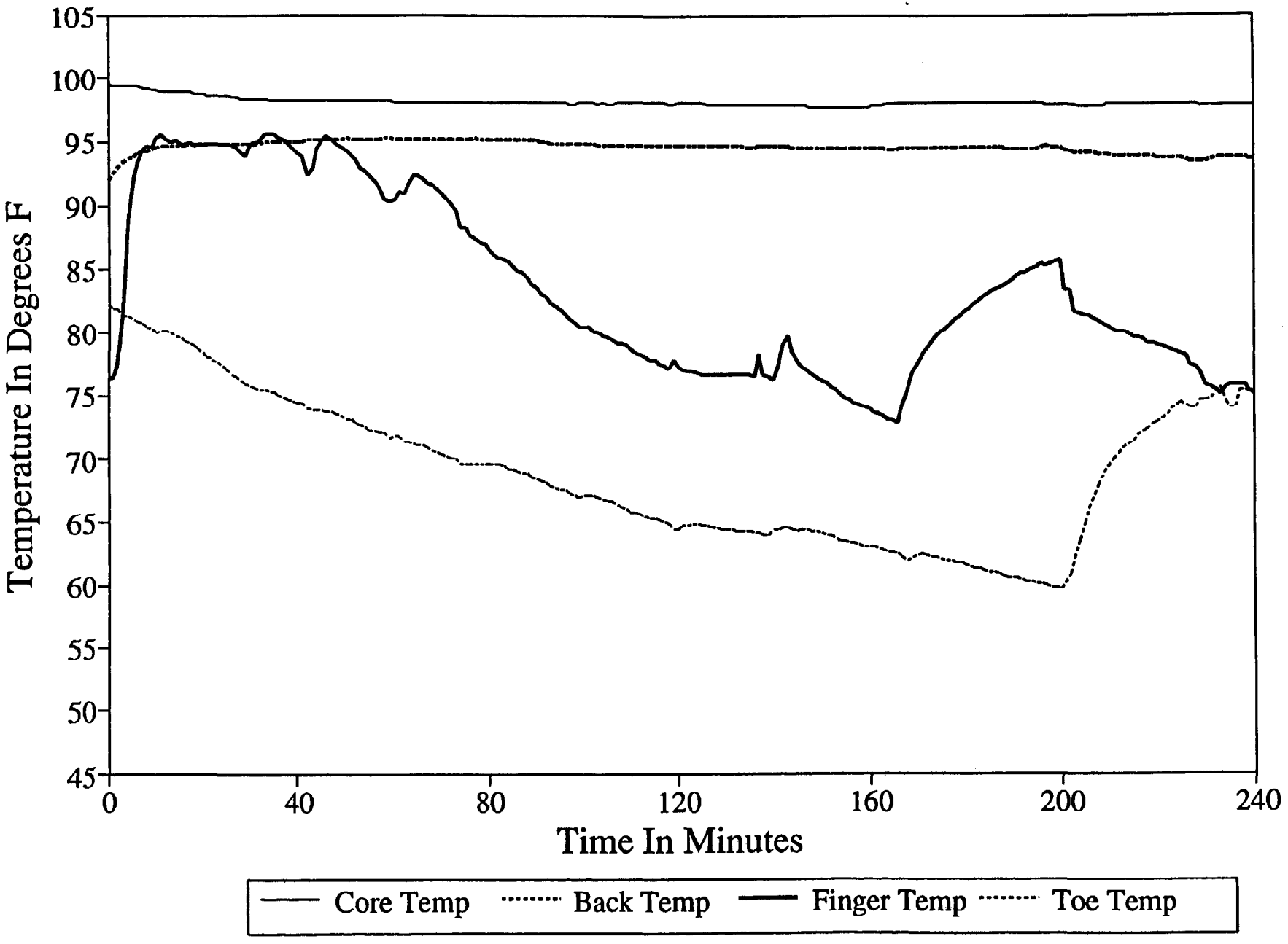

Figure C-24. Subject 4 in sleep system F.

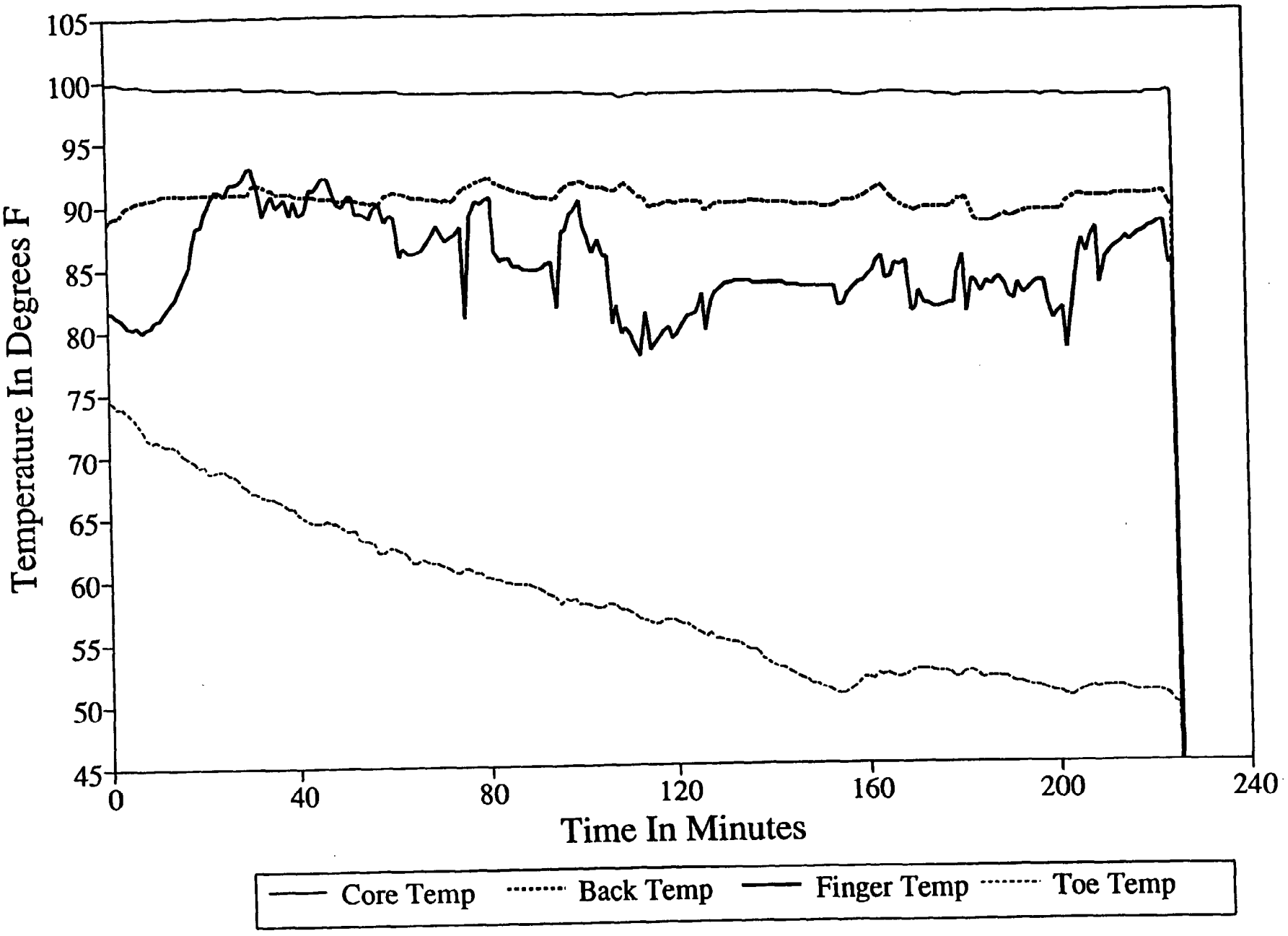

Figure C-25. Subject 1 in sleep system G.

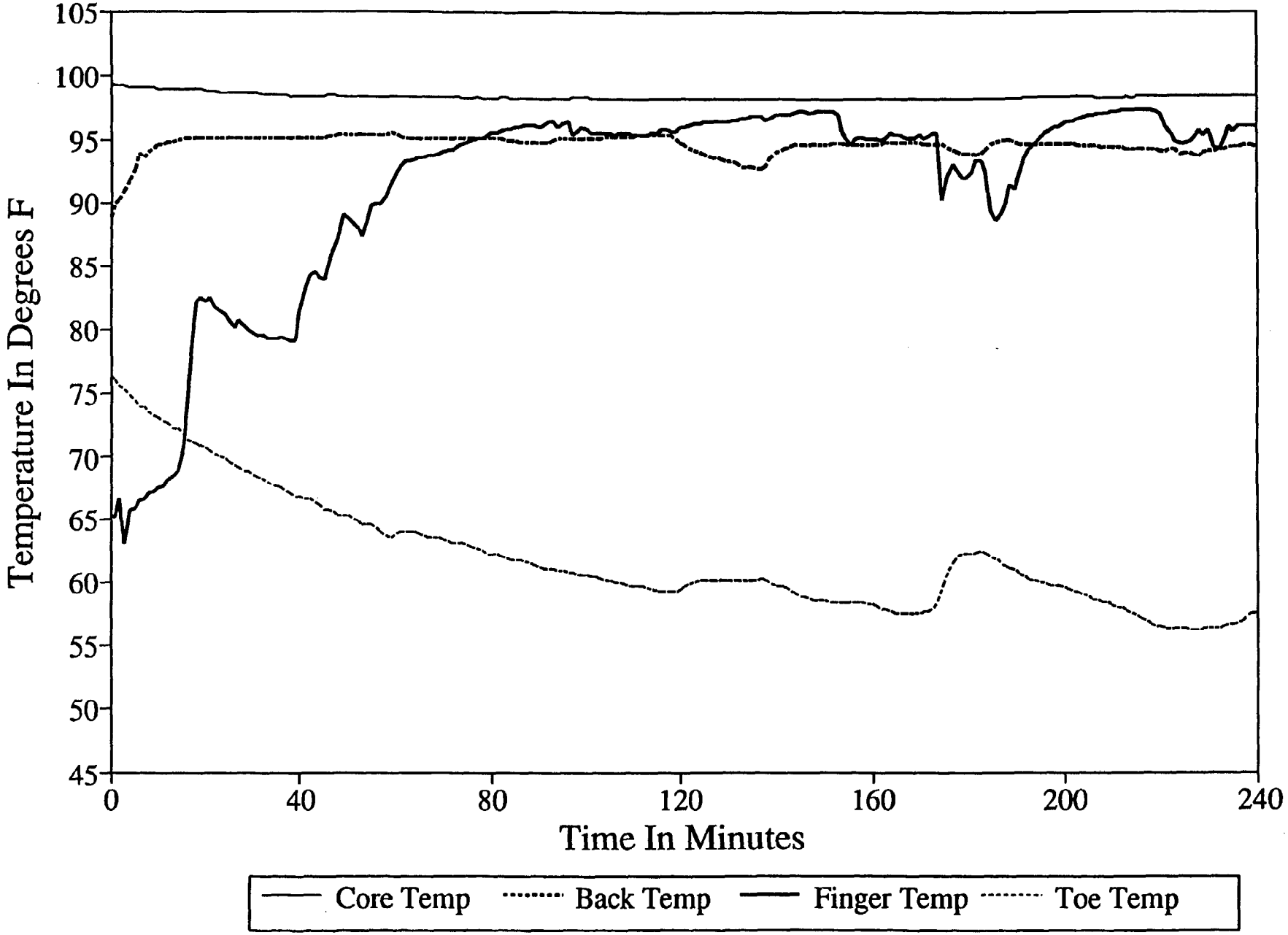

Figure C-26. Subject 2 in sleep system G.

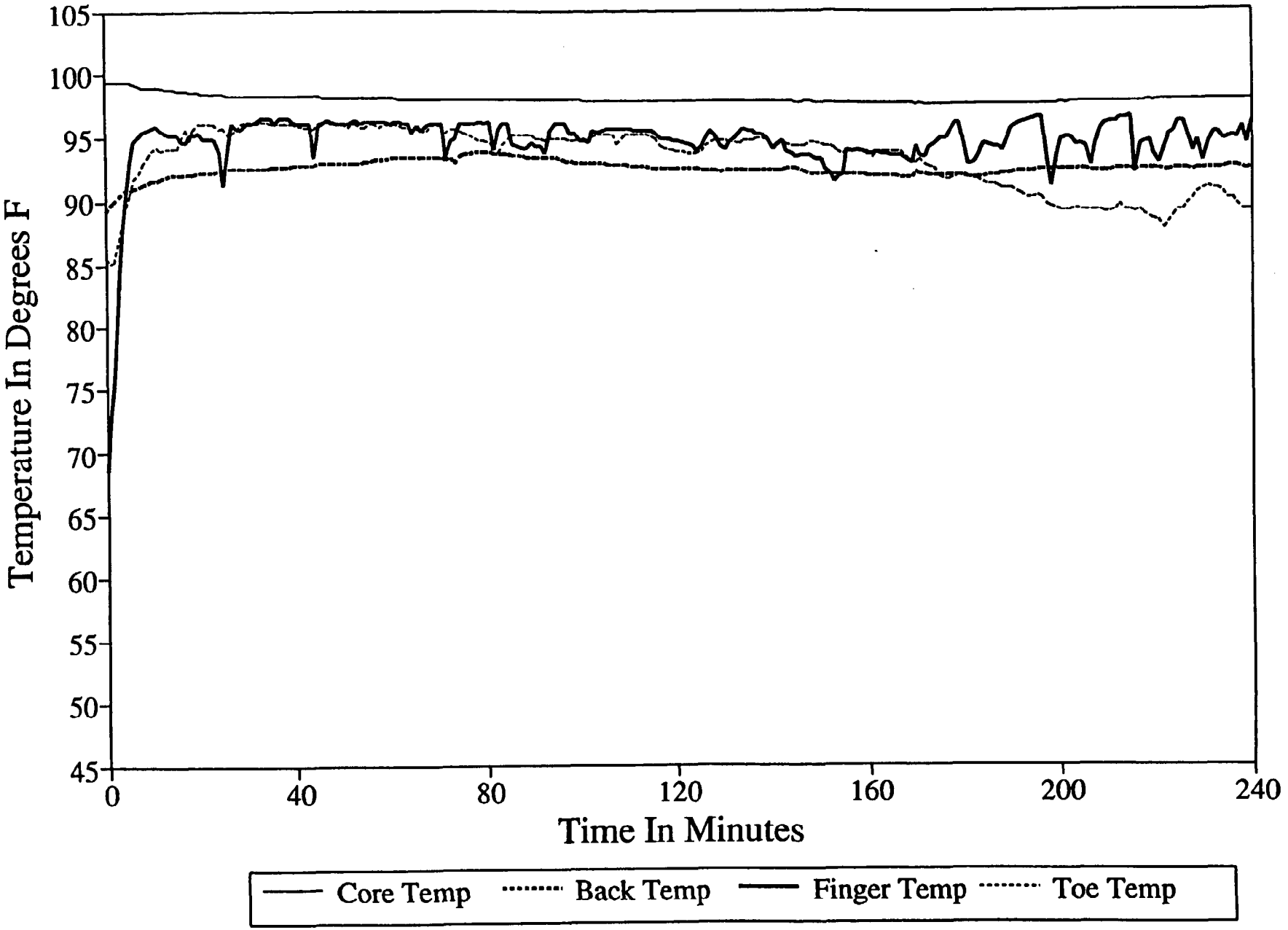

Figure C-27. Subject 3 in sleep system G.

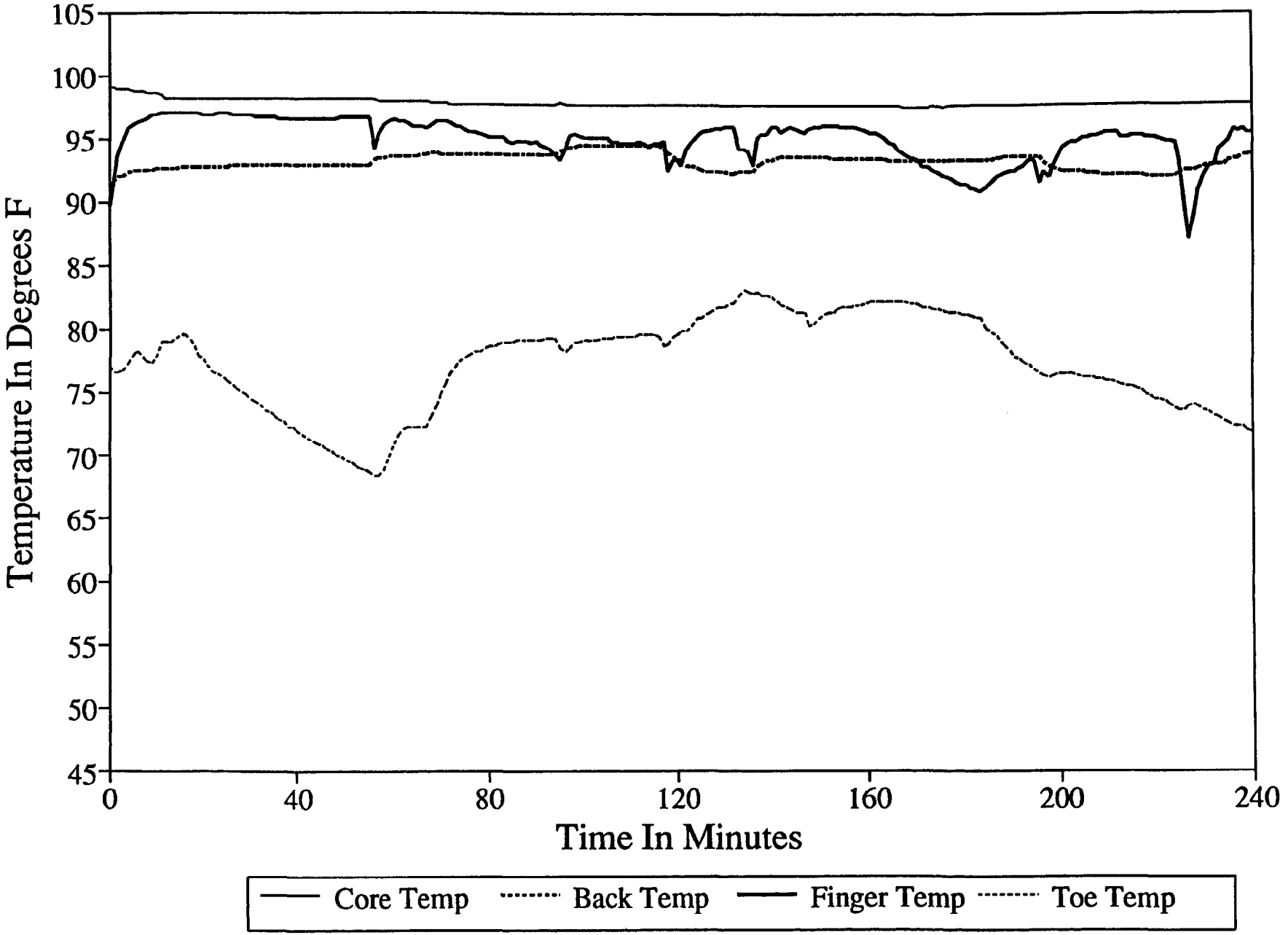

Figure C-28. Subject 4 in sleep system G.

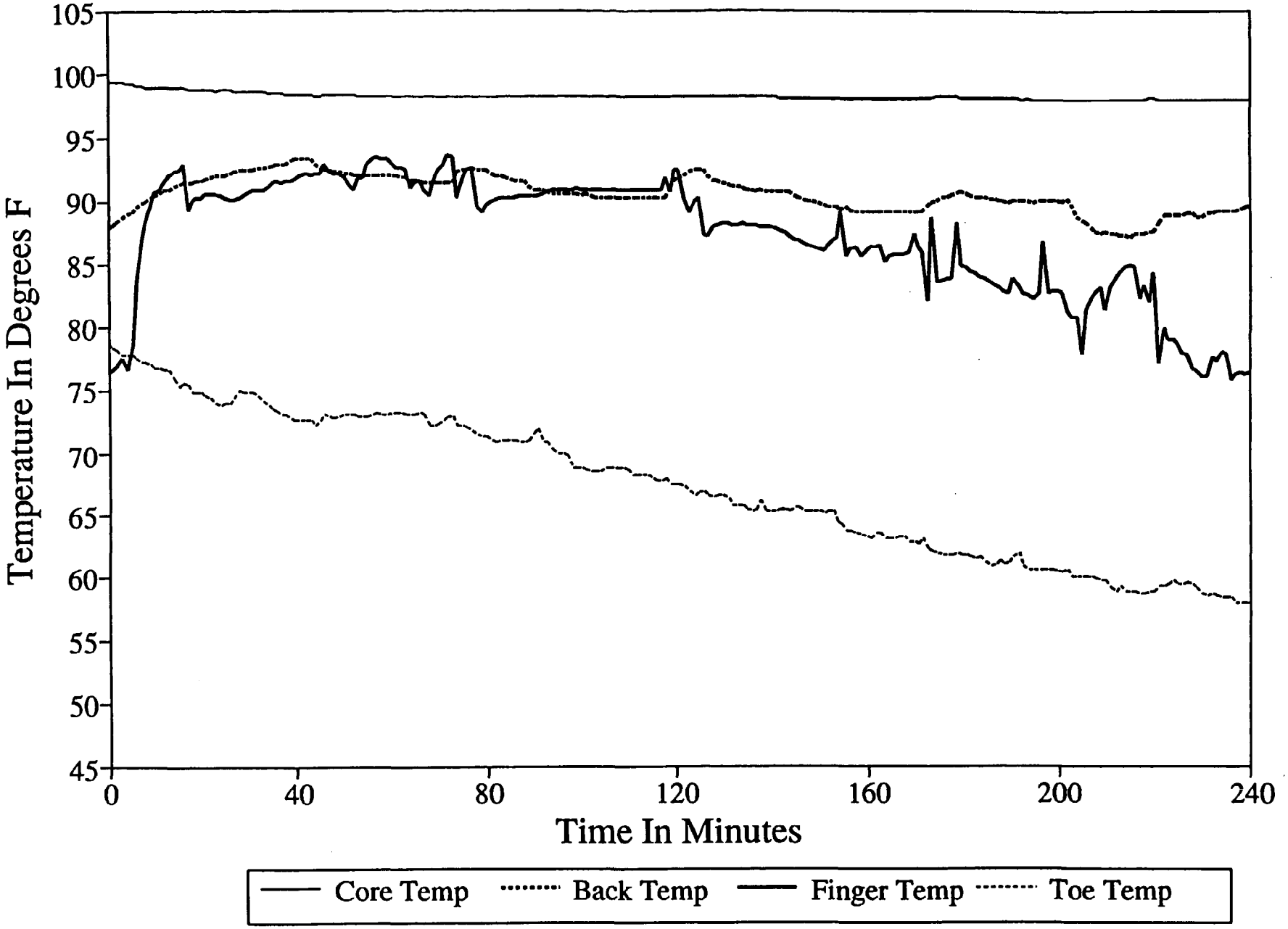

Figure C-29. Subject 1 in sleep system H.

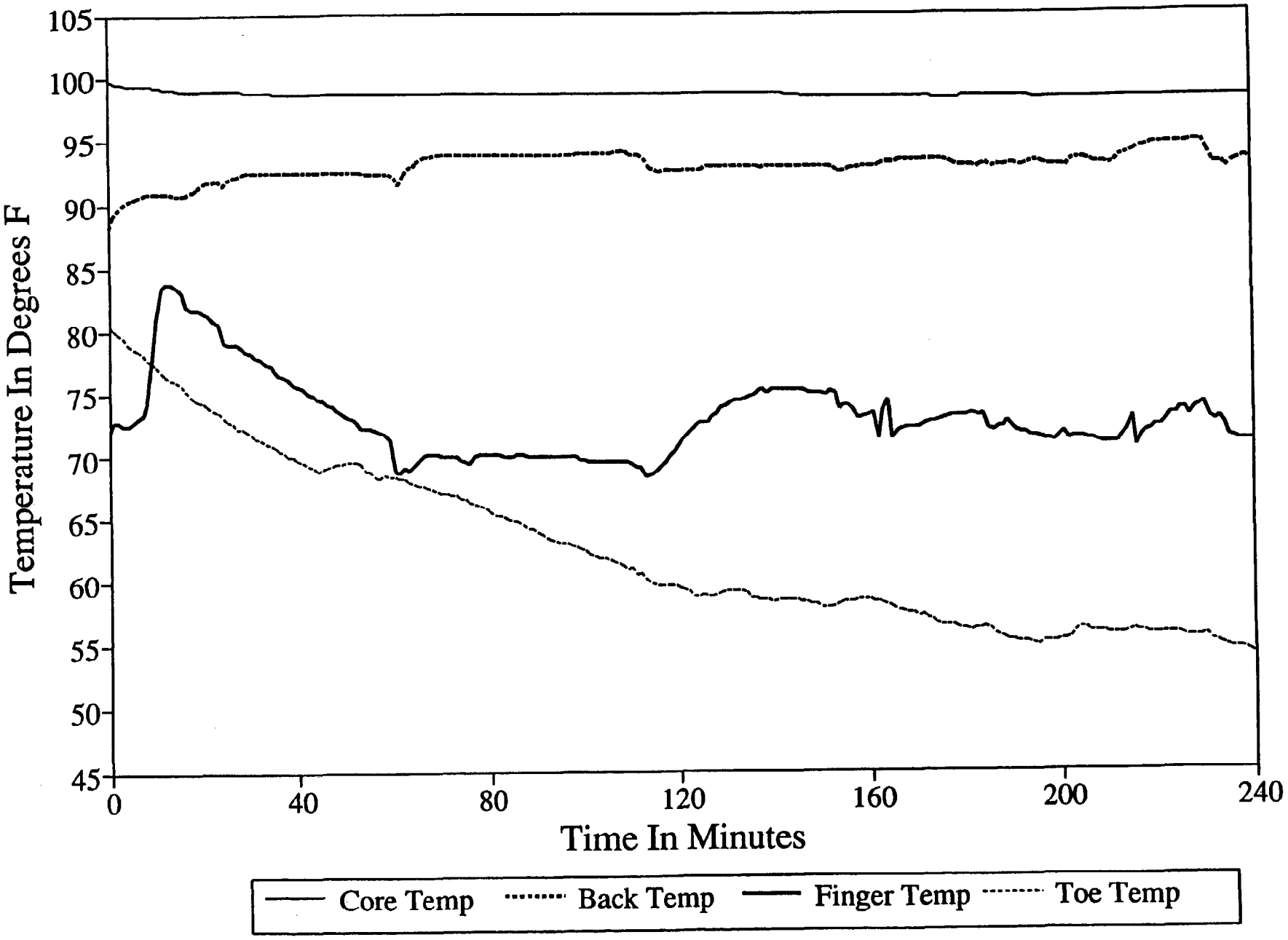

Figure C-30. Subject 2 in sleep system H.

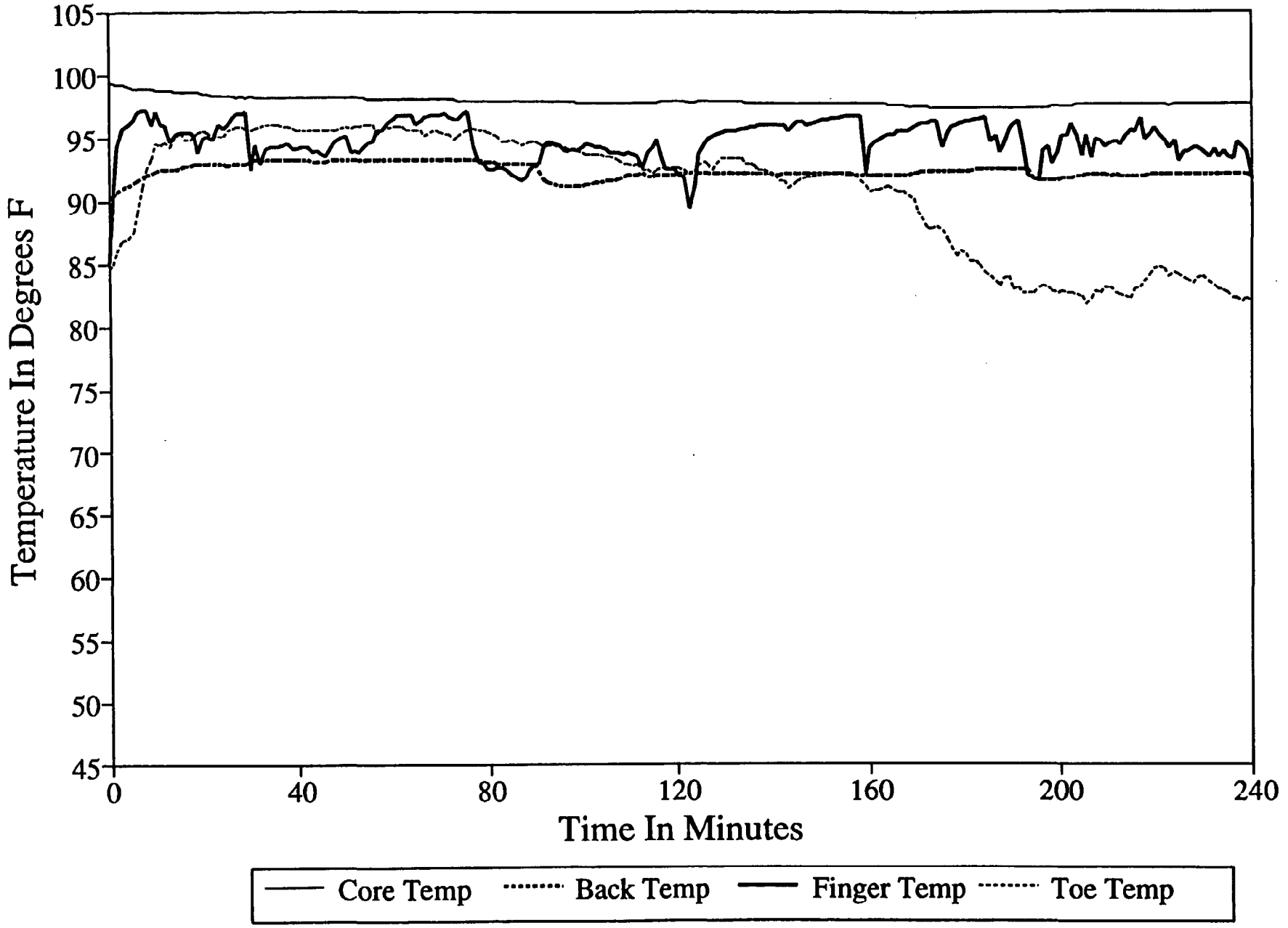

Figure C-31. Subject 3 in sleep system H.

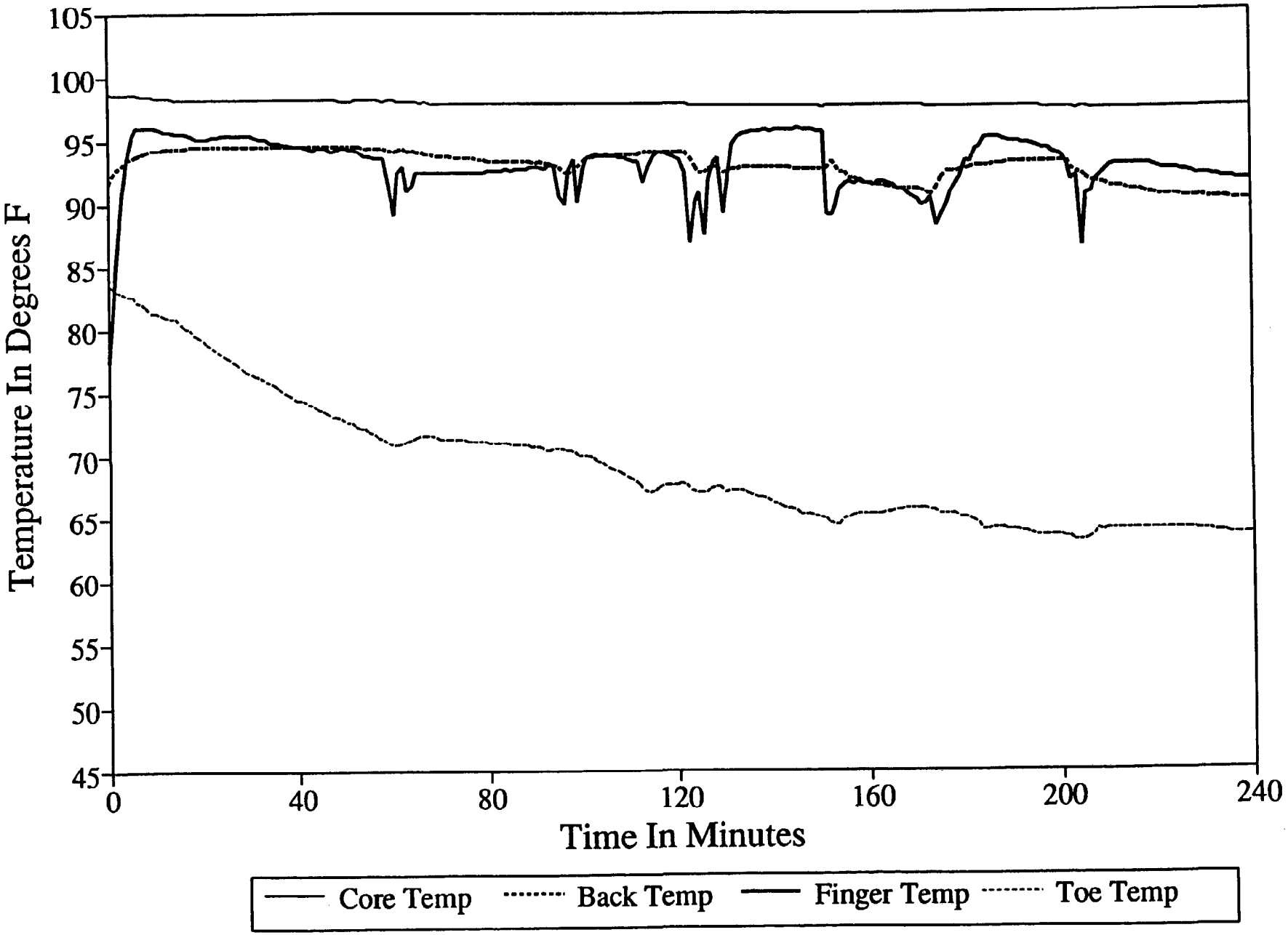

Figure C-32. Subject 4 in sleep system H.

APPENDIX D

SUMMARY OF QUESTIONNAIRE RESPONSES

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SUMMARY OF QUESTIONNAIRE RESPONSES

1. Were you able to warm yourself after entering the sleeping bag?

System A -	Yes (4)	No (0)	System E -	Yes (4)	No (0)
System B -	Yes (4)	No (0)	System F -	Yes (4)	No (0)
System C -	Yes (3)	No (1)	System G -	Yes (3)	No (1)
System D -	Yes (2)	No (2)	System H -	Yes (3)	No (1)

2. If you were able to warm yourself after entering the sleeping bag, how long did it take to feel comfortably warm?

System A - Ss 2 (2-3 min.) Ss 3 (5 min) Ss 4 (15 min)
System B - Ss 1 (NA) Ss 2 (long time) Ss 3 (15 min) Ss 4 (5 min)
System C - Ss 1 (NA) Ss 2 (2-3 min) Ss 3 (5 min) Ss 4 (5 min)
System D - Ss 1 (minutes) Ss 3 (10 min)
System E - Ss 1 (minutes) Ss 2 (3 min) Ss 3 (5 min) Ss 4 (5 min)
System F - Ss 1 (minutes) Ss 2 (minutes) Ss 3 (5 min) Ss 4 (2 min)
System G - Ss 2 (minutes) Ss 3 (10 minutes) Ss 4 (5 min)
System H - Ss 1 (5 min) Ss 2 (20 min) Ss 3 (5 min)

No response indicates subject never felt comfortably warm.

3. Did you remain warm for the entire exposure period?

System A -	Yes (1)	No (3)	System E -	Yes (3)	No (1)
System B -	Yes (1)	No (3)	System F -	Yes (3)	No (1)
System C -	Yes (3)	No (1)	System G -	Yes (3)	No (1)
System D -	Yes (0)	No (4)	System H -	Yes (2)	No (2)

4. If you could not sleep, were you able to rest comfortably during the four-hour exposure period?

System A -	Yes (2)	No (2)	System E -	Yes (3)	No (1)
System B -	Yes (2)	No (2)	System F -	Yes (3)	No (-)
System C -	Yes (3)	No (1)	System G -	Yes (4)	No (0)
System D -	Yes (2)	No (2)	System H -	Yes (2)	No (2)

5. Did you feel any cold spots in any area of this sleeping bag at any time during the scenario

System A -	Zipper (3)	Footbox (2)
System B -	Zipper (2)	Footbox (2) Gap at Hood (1)
System C -	Zipper (2)	Area of Hips to Knees (2)
System D -	Zipper (2)	Footbox (2)
System E -	Zipper (1)	Footbox (1)
System F -	Zipper (1)	Footbox (1)
System G -	Zipper (2)	Mid section of bag (1)
System H -	Zipper (2)	Footbox (1) Back of Hood (1)

SUBJECTIVE COMMENTS NOTED ON QUESTIONNAIRES

System A

1. Cold feet (4)
2. Cold air felt through zipper (3)
3. Need better closure device for draft tube (1)
4. Width of bag restricting (1)
   Both sides of body pressing against inside of bag (1)

System B

1. Cold feet (1)
2. Cold air felt through zipper (3)
3. Cold overall (2)
4. Bag tight at top (1)
5. Cold spot at footbox (1)
6. Back felt cold - bag too thin (2)
7. D ring closure not suitable for military (1)
8. Bag to narrow at chest (1)
9. Hood did not close well - gap (2)

System C

1. Never warmed up (1)
2. Feet very cold (2)
3. Cold in general (1)
4. Cold spot - zipper (1)
5. Hood too large - gap (2)
6. D ring closure not suitable (1)

System D

1. Feet stayed cold (2)
2. Cold air felt in mid back (1)
3. Cold air felt through zipper (2)
4. Draft tube moves away from zipper when bag zipped closed (1)
5. Hood is poorly shaped (1)
6. Feet and toes cold last portion of test (2)

System E

1. Cold feet most of time (1)
2. Excellent bag (1)
3. Bag too narrow from hips to knees (1)
4. Warm upper body whole time (1)
5. Cold air felt at zipper (1)
6. Zipper caught on liner material (2)

System F

1. Good flap on zipper (1)
2. Zipper caught on liner material (1)
3. Hood closure not snug around head (1)
4. Felt cold spot at feet - rewarmed after changing body position (1)

System G

1. Cold spot at zipper (2)
2. Cold feet (1)
3. Bag too narrow at mid section (1)
4. Hood closure not snug around hood (2)
5. Hood poorly shaped (2)
6. Noted gap between hood and bag (1)

System H

1. Bag is too narrow (3)
2. Bag is too short (2)
3. Hood poorly shaped (1)
4. Noted cold spots along zipper (3)
5. Noted cold spot at back of head (1)
6. Felt cold air seeping through top of bag (1)

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