OVERVIEW OF CREW MEMBER ENERGY EXPENDITURE DURING SHUTTLE FLIGHT 61-B EASE/ACCESS TASK PERFORMANCE

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In this paper we report the energy expenditure of Shuttle Flight 61-B crewmembers during extravehicular performance of EASE and ACCESS construction system tasks. These data consist of metabolic rate time profiles correlated with specific EASE and ACCESS tasks and crew comments. Average extravehicular activity (EVA) metabolic rates are computed and compared with those previously reported from previous Apollo, Skylab and Shuttle flights (ref. 1, 2, 3).

These data reflect total energy expenditure and not that of individual muscle groups such as hand and forearm. When correlated with specific EVA tasks and subtasks, the metabolic profile data is expected to be useful in planning future EVA protocols. For example, after experiencing high work rates and apparent overheating during some Gemini EVAs (ref. 4, 5) it was found useful to carefully monitor work rates in subsequent flights to assess the adequacy of cooling garments and as an aid to preplanning EVA procedures.

FLIGHT 61-B EVA-1 ACCESS METABOLIC RATE PROFILES

Figure 1 illustrates the rates of total energy expenditure of each crewmember during the ACCESS phase of EVA-1. The mean metabolic rates were 1144 BTU/Hr for EV1 and 892 BTU/Hr EV2. EV1 and EV2 are crewmember designations. Individual tasks are shown on the top of the figure, coinciding with the timelines. As would be expected, the highest work rates were during the build-up of the bays and again during the disassembly. These data are based on oxygen utilization, the average energy release per unit of oxygen being 4.82 Kcal/liter or 380 BTU/mole (ref. 6). ACCESS required considerable work by the hands, but the total work output does not reflect hand fatigue or difficulties with handgrip strength. EVA crewmembers were asked to comment on relative thermal comfort. For this reason both made multiple comments on hand, foot and extremity cooling. These comments should not be interpreted as complaints, but merely reporting feelings of coolness as the heat removal system operated.

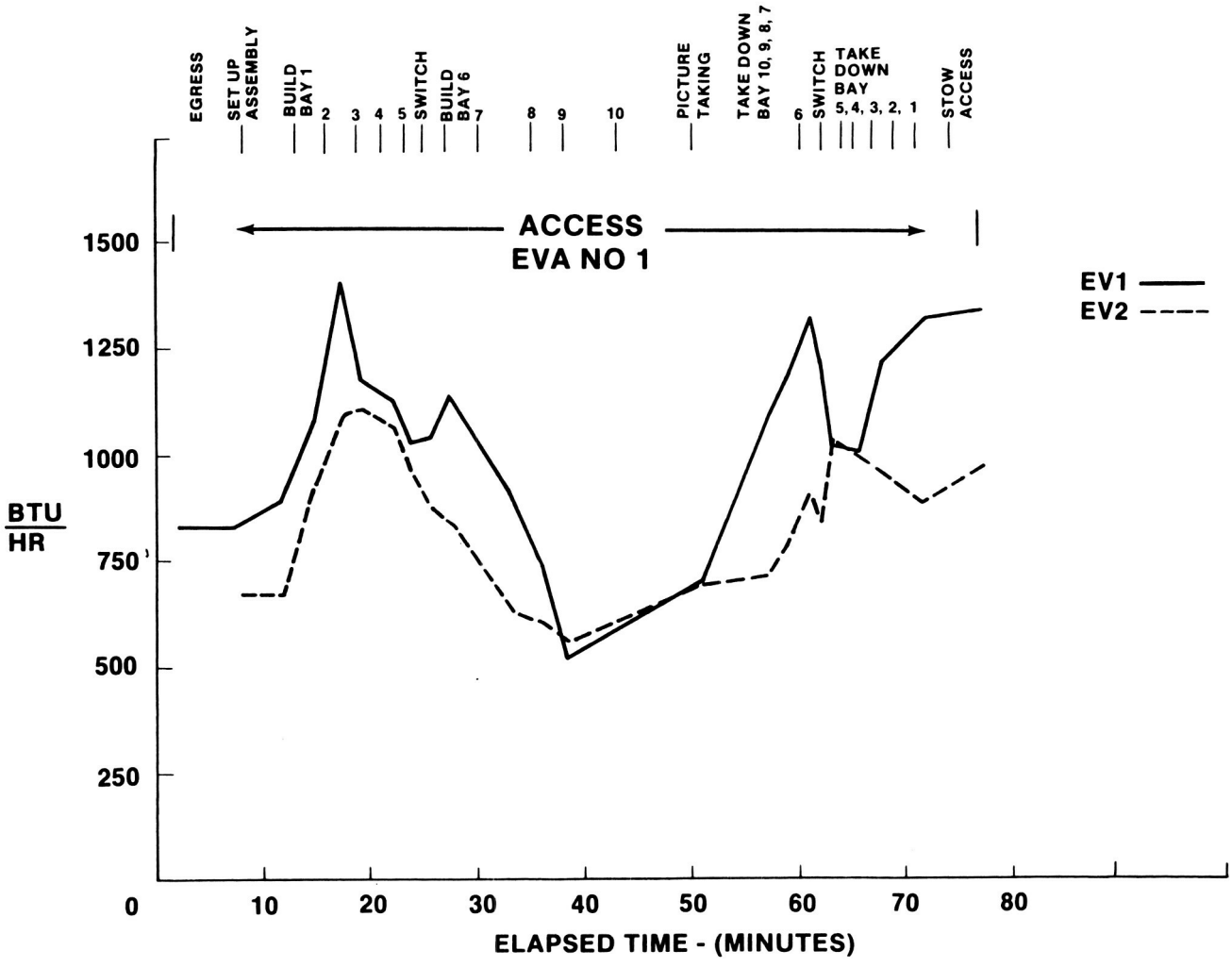

Figure 1

FLIGHT 61-B EVA-2 ACCESS METABOLIC RATE PROFILES

Figure 2 illustrates the rate of energy expenditure of each crewmember as a function of time during the ACCESS portion of EVA-2. The mean metabolic rates for the ACCESS portion of EVA-2 were somewhat lower than during the first EVA (EVA-1), i.e., 924 BTU/Hr for EV1 and 680 BTU/Hr for EV2. Again, the higher rates occurred during the build-up and disassembly of the bays.

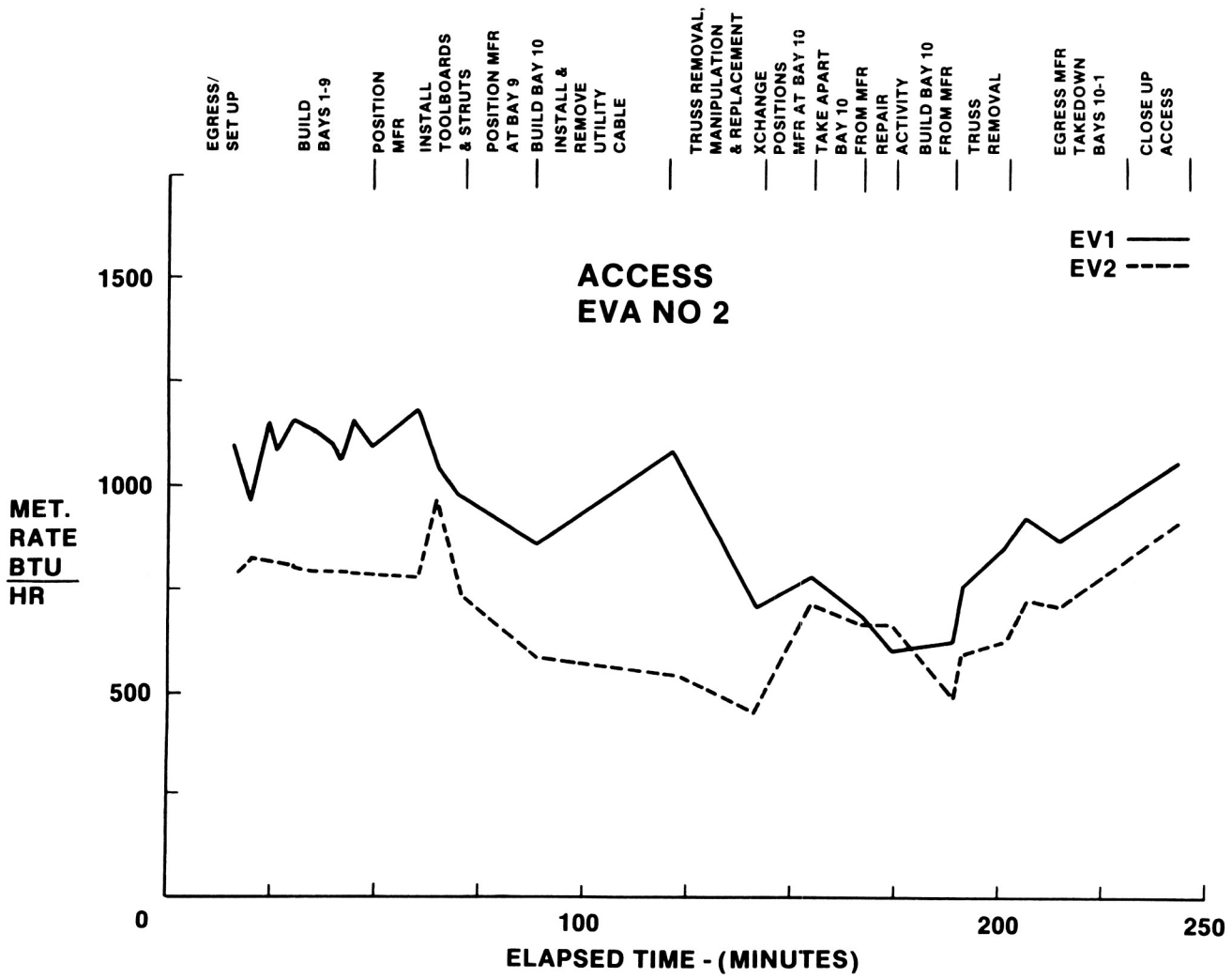

Figure 2

FLIGHT 61-B EVA-1 EASE METABOLIC RATE PROFILES

Figure 3 illustrates the rates of total energy expenditure of each of the two crewmember during the EASE phase of EVA-1. The highest work rates are recorded for EASE 3 and EASE 7 subtasks. EV1 was in the low-man position during the first four assembly/disassembly cycles while EV2 was in the high man position. After they switched positions EV2's work rate increased significantly as he assumed the low-man position. The low man was required to unstow each of the six beams, connect the three vertical beams to the base cluster, translate to the top and help join one of the horizontal beams to the vertical beams, and then rest on the beams as they were removed. Both crewmembers reported that the task was fatiguing for the free-floating crewmember who had to maintain correct body position while using hand and forearm strength to torque the beam into place. This points out the fact that the total metabolic work rates may not reflect the crewmembers' fatigue caused by difficulties with one set of muscles such as the arm and forearm area.

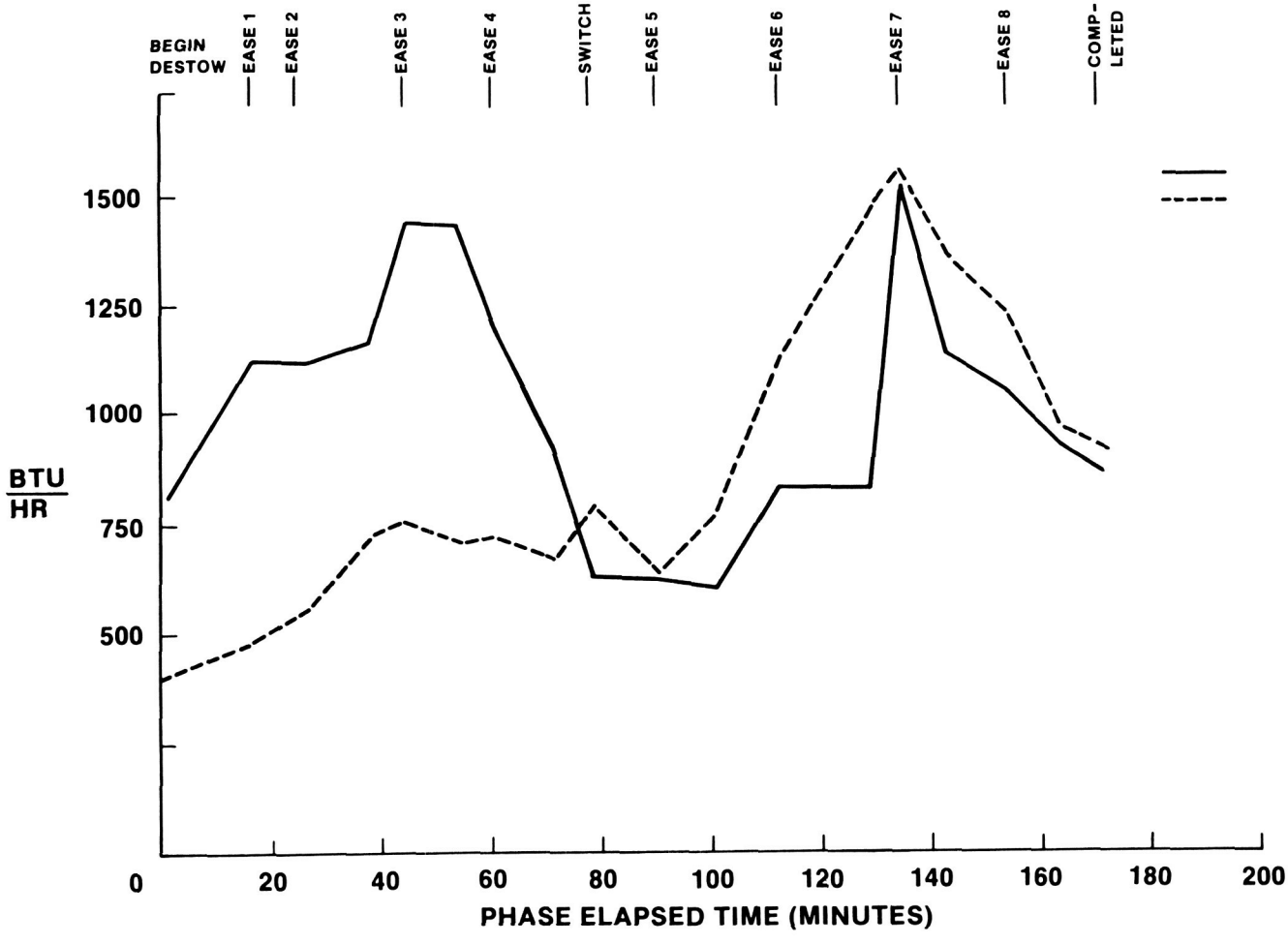

Figure 3

FLIGHT 61-B EASE/ACCESS AVERAGE ENERGY EXPENDITURES

Although metabolic rates are often described as if they were a precise function of a given work task, the variation among individuals reminds us that total metabolism is a function of body mass as well. When the differences in total body energy output during the Flight 61-B EVAs are corrected for body weight, the rates are almost identical for the 2 crewmembers. Table I shows the computations in terms of BTU/Hr and also BTU/Hr/Lb for both EVAs broken down into the ACCESS and EASE phases. The mean metabolic rates are similar in the EASE and ACCESS phases, although the peak metabolic rates during the EASE phase are higher (Fig. 3).

FIRST EVA (61-B) METABOLIC RATES

ACTIVITY	CREWMEMBER (BTU/HR)		CREWMEMBER (BTU/HR/LB)	
	EV 1	EV 2	EV 1	EV 2
ACCESS	1144	892	6.0	6.5
EASE	1084	869	5.7	6.3

SECOND EVA (61-B) METABOLIC RATES

ACTIVITY	CREWMEMBER (BTU/HR)		CREWMEMBER (BTU/HR/LB)	
	EV 1	EV 2	EV 1	EV 2
ACCESS	924	680	4.8	4.9
REMAINDER OF EVA	916	672	4.8	4.9

Figure 4

PROBABILITY DENSITY PLOTS FOR APOLLO, SKYLABS,
AND SHUTTLE METABOLIC RATE DISTRIBUTIONS

These plots, Figure 5, based on estimated means and standard deviations illustrate the spread and central tendency of each of the three sets of average EVA metabolic rate measurement, i.e., Apollo, Skylab and Shuttle. The average metabolic rate during the Apollo EVAs was 235 Kcal/Hr (940 BTU/Hr) and the Skylab EVAs averaged 238 Kcal/Hr (952 BTU/Hr). The average metabolic rate during Shuttle EVAs was somewhat lower at 197 Kcal/Hr (788 BTU/Hr). Although the mean of the Shuttle data is significantly lower than that of previous programs, a wide variation in energy requirement exists, depending on the nature of the EVA task.

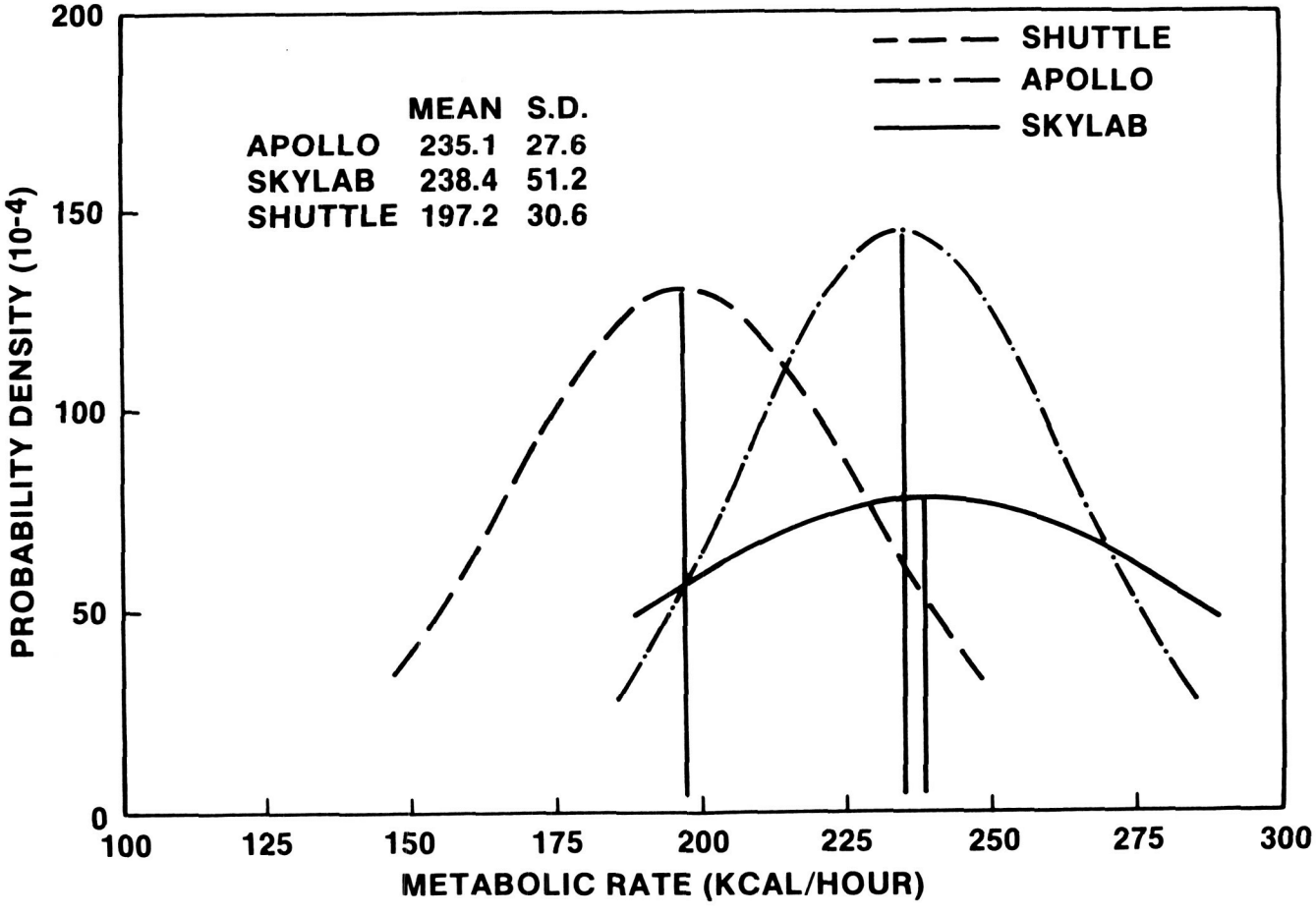

Figure 5

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